



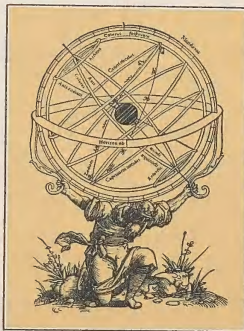
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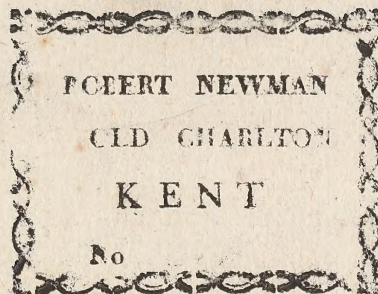
ON THE

MICROSCOPE.

ESSAYS

ON THE

MICROSCOPE.



ROBERT NEWMAN

OLD CHARLTON

KENT

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*Truth discovering to Time, Science
instructing her Children in the Improvements on the Microscope.*

London, Published July 1st 1787, by Geo^r. Adams, N^o 60 Fleet Street.

E S S A Y S
O N T H E
M I C R O S C O P E ;
C O N T A I N I N G
A P R A C T I C A L D E S C R I P T I O N O F T H E M O S T I M P R O V E D
M I C R O S C O P E S :
A G E N E R A L H I S T O R Y o f I N S E C T S ,
T H E I R
T R A N S F O R M A T I O N S , P E C U L I A R H A B I T S , A N D Œ C O N O M Y :
A N A C C O U N T O F T H E
V A R I O U S S P E C I E S A N D S I N G U L A R P R O P E R T I E S O F T H E
H Y D R Œ A N D V O R T I C E L L Œ :
A D E S C R I P T I O N O F
T h r e e H u n d r e d a n d S e v e n t y - N i n e A n i m a l c u l a ,
W I T H A C O N C I S E
C A T A L O G U E O F I N T E R E S T I N G O B J E C T S :
A V I E W O F T H E
O R G A N I Z A T I O N O F T I M B E R ,
A N D T H E
C O N F I G U R A T I O N O F S A L T S W H E N U N D E R T H E M I C R O S C O P E .

B Y G E O R G E A D A M S ,
M A T H E M A T I C A L I N S T R U M E N T M A K E R T O H I S M A J E S T Y , A N D O P T I C I A N
T O H I S R O Y A L H I G H N E S S T H E P R I N C E O F W A L E S .

L O N D O N :

P R I N T E D F O R T H E A U T H O R , B Y R O B E R T H I N D M A R S H , P R I N T E R T O
H I S R O Y A L H I G H N E S S T H E P R I N C E O F W A L E S , N o . 3 2 , C L E R K E N W E L L -
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T O T H E
K I N G.

S I R,

EVERY work that tends to enlarge
the boundaries of science, has a
peculiar claim to the protection of Kings.
He that diffuses science, civilizes man,
opens the inlets to his happiness, and
co-operates with the Fountain and Source
6 of

of all knowledge. By science truth is advanced; and of DIVINE TRUTH Kings are the representatives.

The work which I have now the honour to present to YOUR MAJESTY, calls the attention of the reader to those laws of Divine order by which the universe is governed and supported: in it we find that the minutest beings share in the protection, and triumph in the bounty of the Sovereign of all things: that the infinitely small manifest to the astonished eye the same proportion, regularity, and design, which are conspicuous to the unassisted sight in the larger parts of creation. By
finding

finding all things formed in beauty, and produced for use, the mind is raised from the fleeting and evanescent appearances of matter to contemplate the permanent principles of truth, and acknowledge that the whole proceeds from the wisdom that originates in love.

It was by YOUR MAJESTY's goodness and gracious patronage that I was first induced to undertake a description of mathematical and philosophical instruments, that I might thereby facilitate the attainment of those sciences that are connected with them, and by shewing what was already obtained, excite emulation, and quicken invention.

It

It is to the same goodness that I am indebted for this opportunity of subscribing myself,

S I R,

YOUR MAJESTY'S

Most humble,

Most obedient,

and most dutiful

Subject and Servant,

GEORGE ADAMS.

P R E F A C E.

IN the preface to my ESSAYS ON ELECTRICITY AND MAGNETISM, I informed the public that it was my intention to publish, from time to time, essays describing the construction and explaining the use of mathematical and philosophical instruments, in their present state of improvement. This work will, I hope, be considered as a performance of my promise, so far as relates to the subject here treated of.

The first chapter contains a short history of the invention and improvements that have been made on the microscope, and Father Torrè's method of making his celebrated glass globules. The second treats of vision, in which I have endeavoured to explain, in a familiar manner, the reason of those advantages which are obtained by the use of magnifying lenses; but as the reader is supposed to be unacquainted with the elements of this science, so many intermediate ideas have been necessarily omitted, as must in some degree lessen the force, and weaken the perception of the truths intended to be inculcated: to have given these would have required a treatise on optics.

In the third chapter, the most improved microscopes, and some others which are in general use, are particularly described; no pains have been spared to lessen the difficulty of observation, and remove obscurity from description; the relative advantages of each instrument are briefly pointed out, to enable the reader to select that which is best adapted to his pursuits. The method of preparing different objects for observation, and the cautions necessary to be observed in the use of the microscope, are the subject of the fourth chapter.

When I first undertook the present essays, I had confined myself to a re-publication of my father's work, entitled, *Micrographia Illustrata*; but I soon found that both his and Mr. Baker's tracts on the microscope were very imperfect. Natural history had not been so much cultivated at the period when they wrote, as it is in the present day. To the want of that information which is now easily obtained, we may, with propriety, impute their errors and imperfections. I have endeavoured to remedy their defects, by arranging the subjects in systematic order, and by introducing the microscopic reader to the system of Linnæus, as far as relates to insects: by this he will learn to discriminate one insect from another, to characterize their different parts, and thus be better enabled to convey instruction to others, and to avoid error himself.

As the transformations which insects undergo, constitute a principal branch of their history, and furnish many objects for the microscope, I have given a very ample description of them; the more so, as many microscopic writers, by not considering these changes with attention, have fallen into a variety of mistakes.

Here

Here I intended to stop ; but the charms of natural history are so seducing, that I was led on to describe the peculiar and striking marks in the œconomy of these little creatures. And should the purchaser of these essays receive as much pleasure in reading this part as I did in compiling it ; should it induce him to study this branch of nature ; nay, should it only lead him to read the stupendous work of the most excellent Swammerdam, he will have no reason to regret his purchase, and one of my warmest wishes in compiling it will be gratified.

In the next chapter I have endeavoured to give the reader some idea of Mr. Lyonet's " anatomical and microscopical description of the cossus, or caterpillar of the willow." As this book is but little known in our country, I thought that a specimen of the indefatigable labour of this patient and humane anatomist would be acceptable to all lovers of the microscope ; and I have, therefore, appropriated a plate, which, while it shews what may be effected when microscopic observation is accompanied by patience and industry, displays also the wonderful organization of this insect. This is followed by a description of many miscellaneous objects ; objects, of which no idea could be formed without the assistance of glasses.

To describe the fresh-water polype, or hydra ; to give a short history of the discovery of these curious animals, and some account of their singular properties, is the business of the succeeding chapter. The properties of these animals are so extraordinary, that they were considered at first to be as contrary to the common course of nature, as they really were to the received opinions of animal life. Indeed, who can even now contemplate, without

astonishment, animals that multiply by slips and shoots like a plant, that may be grafted together as one tree to another, that may be turned inside out like a glove, and yet live, act, and perform all the various functions of their little spheres. As nearly allied to these, the chapter finishes with an account of those vorticellæ which have been enumerated by Linnæus. It has been my endeavour to dissipate confusion, by the introduction of order, to dispose into method, and select under proper heads the substance of all that is known relative to these little creatures, and in the compass of a few pages to give the reader the information that is dispersed through volumes.

From the hydræ and vorticellæ it was natural to proceed to the animalcula which are to be found in vegetable infusions. Microscopic beings, that seem as it were to border on the infinitely small, that leave no space destitute of inhabitants, and are of greater importance in the immense scale of beings than our contracted imagination can conceive, yet small as they are, each of them possesses all that beauty and proportion of organized texture which is necessary to its well being, and suited to the happiness it is called forth to enjoy. I have pointed out the decided characters which fix them in the scale of animal life, characters that it is presumed are a full confutation of the fanciful theories of Needham and Buffon. A short account of three hundred and seventy-nine of these minute beings is then given, agreeable to the system of the laborious Muller,* enlarging considerably his description of those animalcula that are most easily met with, better known, and consequently more interesting to the generality of readers.

The

* Muller, *Animalcula Infusoria*.

The construction of timber, and the disposition of it's component parts, as seen by the microscope, is the subject of the next chapter; a subject confessedly obscure. With what degree of success this attempt has been prosecuted, must be left to the judgment of the reader. The best treatise on this part of vegetation is that of Mr. Duhamel du Monceau "sur la Physique des Arbres." If either my time, or situation in life, would have permitted it, I should have followed his plan; but being confined to business, and to London, I can only recommend it to those lovers of the works of the Almighty, who live in the country, to pursue this important branch of natural history. There is no doubt but that new views of the operations in nature, and of the wisdom with which all things are contrived, would amply repay the labour of investigation. Every part of the vegetable kingdom is rich in microscopic beauties, from the stateliest tree of the forest, from the cedar of Lebanon, to the lowliest moss, and the hyssop that springeth out of the wall, all conspiring to say how much is hid from the natural sight of man, how little can be known till it receives assistance, and is benefited by adventitious aid.

From the wonderful organization of animals, and the curious texture of vegetables, we proceed to the mineral kingdom, and take a cursory view of the configuration of salts and saline substances, exhibiting a few specimens of the beautiful order in which they arrange themselves under the eye, after having been separated by dissolution: every species working as it were upon a different plan, and producing cubes, pyramids, hexagons, or
some

some other figure peculiar to itself, with a constant regularity amidst boundless variety.

Though all nature teems with objects for the microscopic observer, yet such is the indolence of the human mind, or such its inattention to what is obvious, that among the purchasers of microscopes many have complained that they knew not what subjects to apply to their instrument, or where to find objects for examination. To obviate this complaint, a catalogue is here given, which is interspersed with the description of a few insects, and other objects, which could not be conveniently introduced in the foregoing chapters. By this catalogue it is hoped that the use of the microscope will be extended, and the path of observation facilitated.

To avoid the fastidious parade of quotation, and the charge of plagiarisim, I have subjoined to this preface a list of the authors I have consulted. As my extracts were made at very distant periods, it would have been impossible for me to remember to whom I was indebted for every new fact, or ingenious observation. It may, however, be necessary to inform the reader, that Mr. Marshall gave me the Linnæan names for the insects which are described in this work.

The plates were drawn and engraved with a view to be folded up with the work; but as it is the opinion of many of my friends that they would, by this means, be materially injured, I have been advised to have them stitched in strong blue paper, and leave it to the purchaser to dispose of them to his own mind.

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ESSAYS

ESSAYS

ON THE

MICROSCOPE.

CHAP. I.

A CONCISE HISTORY OF THE INVENTION AND IMPROVEMENTS WHICH HAVE BEEN MADE UPON THE INSTRUMENT CALLED A MICROSCOPE.

IT is generally supposed, that microscopes were invented about the year 1680, a period fruitful in discoveries, a time when the mind began to emancipate itself from those errors and prejudices by which it had been too long enslaved, to assert it's rights, extend it's powers, and follow the paths which lead to truth. The honor of the invention is claimed by the Italians and the Dutch; the name of the inventor, however, is lost; probably the discovery did not at first appear sufficiently important, to engage the attention of those men, who, by their reputation in science, were able to establish an opinion of it's

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merit with the rest of the world, and hand down the name of the inventor to succeeding ages. Men of great literary abilities are too apt to despise the first dawnings of invention, not considering that all real knowledge is progressive, and that what they deem trifling may be the first and necessary link to a new branch of science.

The microscope extends the boundaries of the organs of vision, enables us to examine the structure of plants and animals; presents to the eye myriads of beings, of whose existence we had before formed no idea; opens to the curious an exhaustless source of information and pleasure; and furnishes the philosopher with an unlimited field of investigation. It leads, to use the words of an ingenious writer, to the discovery of a thousand wonders in the works of his hand, who created ourselves, as well as the objects of our admiration; it improves the faculties, exalts the comprehension, and multiplies the inlets to happiness; is a new source of praise to him, to whom all we pay is nothing of what we owe; and while it pleases the imagination with the unbounded treasures it offers to the view, it tends to make the whole life one continued act of admiration.

It is not difficult to fix the period when the microscope first began to be generally known, and was used for the purpose of examining minute objects; for though we are ignorant of the name of the first inventor, we are acquainted with the names of those who introduced it into public view, and engaged their attention to it, by exhibiting some of its wonderful effects. Zacharias Jansens and his son had made microscopes before the year 1619, for in that year the ingenious Cornelius Drebell

brought one, which was made by them, with him into England, and shewed it to William Borrell and others. It is possible this instrument of Drebell's was not strictly what is now meant by a microscope, but was rather a kind of microscopic telescope, something similar in principle to that lately described by Mr. Aepinus, in a letter to the Academy of Sciences at Petersburg. It was formed of a copper tube six feet long and one inch diameter, supported by three brass pillars in the shape of dolphins; these were fixed to a base of ebony, on which the objects to be viewed by the microscope were also placed. In contradiction to this, Fontana, in a work which he published in 1646, says, that he had made microscopes in the year 1618: this may be also very true, without derogating from the merit of the Jansens, for we have many instances in our own times of more than one person having executed the same contrivance, nearly at the same time, without any communication from one to the other. In 1685, Stelluti published a description of the parts of a bee, which he had examined with a microscope.

If we consider the microscope as an instrument consisting of one lens only, it is not at all improbable, that it was known to the ancients much sooner than the last century, nay, even in a degree to the Greeks and Romans: for it is certain, that spectacles were in use long before the above-mentioned period: now as the glasses of these were made of different convexities, and consequently of different magnifying powers, it is natural to suppose, that smaller and more convex lenses were made, and applied to the examination of minute objects. In this sense, there is also some ground for thinking the ancients were not ignorant of the use of lenses, or at least of what approached nearly to, and might

in some instances be substituted for them. The two principal reasons which support this opinion are, first, the minuteness of some ancient pieces of workmanship, which are to be met with in the cabinets of the curious: the parts of some of these are so small, that it does not appear at present how they could have been executed without the use of magnifying glasses, or of what use they could have been when executed, unless they were in possession of glasses to examine them with. A remarkable piece of this kind, a seal with very minute work, and which to the naked eye appears very confused and indistinct, but beautiful when examined with a proper lens, is described "Dans l'Histoire de l'Academie des Inscriptions," tom. 1. p. 333. The second argument is founded on a great variety of passages, that are to be seen in the works of Jamblichus, Pliny, Plutarch, Seneca, Agellius, Pisidias, &c.. From these passages it is evident that they were enabled by some instrument, or other means, not only to view distant objects, but also to magnify small ones; for if this is not admitted, the passages appear absurd, and not capable of having a rational meaning applied to them. I shall only adduce a short passage from Pisidias, a christian writer of the seventh century, Τα μελλοντα ως δια διοπτρου συ βλεψεις: "You see things future by a *dioptrum*:" now we know of nothing but a prospective glass or small telescope, whereby things at a distance may be seen as if they were near at hand, the circumstance on which the simile was founded. It is also clear, that they were acquainted with, and did make use of that kind of microscope, which is even at this day commonly sold in our streets by the Italian pedlars, namely, a glass bubble filled with water. Seneca plainly affirms it, *Literæ quamvis minutæ et obscuræ, per vitream pilam aquâ plenam, majores clarioresque cernuntur.*" Nat. Quæst. lib. 1. cap. 7. "Letters, though minute
and

and obscure, appear larger and clearer through a glass bubble filled with water." Those who wish to see further evidence concerning the knowledge of the ancients in optics, may consult Smith's Optics, Dr. Priestley's History of Light and Colours, the Appendix to an Essay on the first Principles of Natural Philosophy by the Rev. Mr. Jones, Dr. Rogers's Dissertation on the Knowledge of the Ancients, and Mr. Duten's Enquiry into the Origin of the Discoveries attributed to the moderns.

The history of the microscope, like that of nations and arts, has had it's brilliant periods, in which it has shone with uncommon splendor, and been cultivated with extraordinary ardour; these have been succeeded by intervals marked with no discovery, and in which the science seemed to fade away, or at least lie dormant, till some favorable circumstance, the discovery of a new object, or some new improvement in the instruments of observation, awakened the attention of the curious, and animated their researches. Thus, soon after the invention of the microscope, the field it presented to observation was cultivated by men of the first rank in science, who enriched almost every branch of natural history, by the discoveries they made with this instrument: there is indeed scarce any object so inconsiderable, that it has not something to invite the curious eye to examine it; nor is there any, which, when properly examined, will not amply repay the trouble of investigation.

I shall first speak of the SINGLE MICROSCOPE, not only as it is the most simple, but because, as we have already observed, it was invented and used long before the double or compound microscope. When the lenses of the single microscope are very convex,

vex, and consequently the magnifying power very great, the field of view is so small, and it is so difficult to adjust with accuracy their focal distance, that it requires some practice to render the use thereof familiar; at the same time, the smallness of the aperture to these lenses has been found injurious to the eyes of some observers: notwithstanding, however, these defects, the great magnifying power, as well as the distinct vision which is obtained by the use of a deep single lens, more than counterbalances every difficulty and disadvantage. It was with this instrument that Leeuwenhoek and Swammerdam, Lyonet and Ellis examined the minima of nature, laid open some of her hidden recesses, and by their example stimulated others to the same pursuit.

The construction of the single microscope is so simple, that it is susceptible of but little improvement, and has therefore undergone but few alterations; and these have been chiefly confined to the mode of mounting it, or the additions to its apparatus. The greatest improvement this instrument has received, was made by Dr. Lieberkuhn, about the year 1740; it consisted in placing the small lens in the center of a highly-polished concave speculum of silver, by which means he was enabled to reflect a strong light upon the upper surface of an object, and thus examine it with great ease and pleasure. Before this contrivance, it was almost impossible to examine small opaque objects with any degree of exactness and satisfaction; for the dark side of the object being next the eye, and also overshadowed by the proximity of the instrument, its appearance was necessarily obscure and indistinct.

Dr.

Dr. Lieberkuhn adapted a microscope to every object; they consisted of a short brass tube, at the eye end of which a concave silver speculum was fixed, and in the center of the speculum a magnifying lens: the object was placed in the middle of the tube, and had a small adjustment to regulate it to the focus; at the other end of the tube there was a plano convex lens, to condense and render more uniform the light which was reflected from the mirror. But all this pains was not bestowed upon trifling objects; his were generally the most curious anatomical preparations, a few of which, with their microscopes, are (I believe) deposited in the British Museum. It will be proper, in this place, to give some account of M. Leeuwenhoek's microscopes, which were rendered famous throughout all Europe, on account of the numerous discoveries he had made with them, as well as from his afterwards bequeathing a part of them to the Royal Society. The microscopes he used were all single, and fitted up in a convenient simple manner; each of them consisted of a very small double convex lens, let into a socket between two plates rivetted together, and pierced with a small hole; the object was placed on a silver point or needle, which, by means of screws adapted for that purpose, might be turned about, raised or depressed at pleasure, and thus be brought nearer to, or be removed farther from the glass, as the eye of the observer, the nature of the object, and the convenient examination of its parts required. M. Leeuwenhoek fixed his objects, if they were solid, to the foregoing point with glue; if they were fluid, he fitted them on a little plate of talc, or exceeding thin blown glass, which he afterwards glued to the needle, in the same manner as his other objects. The glasses were all exceeding clear, and of different magnifying powers, which were proportioned to the nature of the object, and
the

the parts designed to be examined. But none of those, which were presented to the Royal Society, magnified so much, as the glass globules, which have been used in other microscopes. He had observed, in a letter of his to the Royal Society, that from upwards of forty years experience, he found that the most considerable discoveries were to be made with such glasses, as, magnifying but moderately, exhibited the object with the most perfect brightness and distinctness. Each instrument was devoted to one or two objects: hence he had always some hundreds by him.* There is some reason for supposing, that Leeuwenhoek was acquainted with a mode of viewing opaque objects, similar to that invented by Dr. Lieberkuhn.†

About the year 1665, small glass globules began to be occasionally applied to the single microscope, instead of convex lenses. By these globules, an immense magnifying power is obtained. The invention of them has been generally attributed to M. Hartsoeker; it appears, however, to me, that we are indebted to the celebrated Dr. Hooke for this discovery; for he described the manner of making them in the preface to his *Micrographia Illustrata*, which was published in the year 1656. Now the first account we have of any microscopical discovery by M. Hartsoeker, was that of the spermatæ animalculæ, made by him when he was eighteen years old; which brings us down to the year 1674, long after Dr. Hooke's publication.

As these glass globules have been very useful in the hands of experienced observers, I shall lay before my readers the different

* Philosophical Transactions, No. 380, No. 458.

† Priestley's History of Optics, p. 220.

different modes which have been described for making them, that he may be enabled thereby to verify or confute the discoveries that have been said to be made with them.

Take a small rod * of the clearest and cleanest glass you can procure, free, if possible, from blebs, veins, or sandy particles; then by melting it in a lamp made with spirit of wine, or the purest and clearest fallad oil, draw it out into exceeding fine and small threads; take a small piece of these threads, and melt the end thereof in the same flame, till you perceive it run into a small drop or globule of the desired size; let this globule cool, then fix it upon a thin plate of brass or silver, so that the middle of it may be directly over the center of a very small hole made in this plate, handling it till it is fixed; by the before-mentioned thread of glass. When the plate is properly fixed to your microscope, and the object adjusted to the focal distance of the globule, you will perceive the object distinctly and immensely magnified. By this means, says Dr. Hooke, I have been able to distinguish the particles of bodies, not only a million of times smaller than a visible point, but even to make those visible whereof a million of millions would hardly make up the bulk of the smallest visible grain of sand; so prodigiously do these exceeding small globules enlarge our prospect into the more hidden recesses of nature.

Mr. Butterfield, in making of the globules, used a lamp with spirit of wine; but instead of a cotton wick, he used fine silver wire, doubled up and down like a skain of thread. † He prepared

B

* Lectures and Collections by Dr. Hooke.

† Philof. Transf. No. 141.

pared his glass by beating it to powder, and washing it very clean; he then took a little of this glass upon the sharp point of a silver needle, wetted with spittle, and held it in the flame, turning it about till a glass ball was formed; then taking it from the flame, he afterwards cleaned it with soft leather, and set it in a brass cell.

No person has carried the use of these globules so far as T. Di Torrè, of Naples, nor been so dexterous in the execution of them; and if others have not been able to follow him in the same line, it may be fairly attributed to a want of that delicacy of touch for adjusting the objects to their focus, and that acuteness of vision which can only be acquired by long practice. P. Torrè has also described, more minutely than any other author, the mode of executing these globules, which, as it throws much light upon the preceding description by Dr. Hooke, will not, it is presumed, be unacceptable to the reader.

Three things are necessary for forming of these globules:

1. A lamp and bellows, such as are used by the glass-blowers;
2. A piece of perfect tripoli;
3. A variety of small glass rods.

When the flame of the lamp is blown in an horizontal direction, it will be found to consist of two parts; from the base to about two-thirds of its length, it is of a white colour; beyond this, it is transparent, and colourless. It is this transparent part which is to be used for melting the glass, because by this it will not be in the least sullied; but it will be immediately soiled, if it touches the white part of the flame. The part of the glass which is presented to the flame, ought to be exceeding clean, and great care should be taken that it be not touched by the fingers. If the

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glass

glass rod has contracted any spots, it must either be thrown away, or the parts that are spotted must be cut off.

The piece of tripoli which is to be used in forming the globules, should be flat on one side, and so large, that it may be handled conveniently, and protect the fingers from the flame. A piece four or five inches long, and three or four inches thick, will answer very well. The best tripoli for this purpose, is of a white colour, with a fine grain, heavy and compact, and which, after it has been calcined, is of a red colour. This kind resists the fire best, is not apt to break when calcined, and the melted glass does not adhere to it. To calcine this tripoli, cover it well all round with charcoal nearly red hot, leaving it thus till the charcoal is quite cold; it may then be taken out. Let several hemispherical cavities be made on the flat side of the tripoli; they should be of different sizes, nicely polished, and neatly rounded at the edges, in order to facilitate the entrance of the flame. The large globules are to be placed in the large cavities, and the minuter ones in the small cavities. The holes in the tripoli must never be touched with the finger. If it is necessary to clean them, it should be done with white paper; the larger globules may be cleaned with wash leather. The glass rods should be of various sizes, as of 1-10th, 1-20th, 1-30th of an inch in diameter, as clean and free from specks and bubbles as possible.

TO MAKE SMALL GLASS MICROSCOPIC GLOBULES.

Take two rods of glass, one in each hand, place their extremities close to each other, and in the purest part of the flame; when you perceive the ends to be fused, separate them from each

other; the heated glass following each rod, will be finer, in proportion to the length it is drawn to and the smallness of the rod; in this manner you may procure threads of glass of any degree of fineness. Direct the flame to the middle of the thread, and it will be instantly divided into two parts. When one of the threads is perfectly cool, place it at the extremity of the flame, by which it will be rendered round; and if the thread of glass be very fine, an exceeding small globule will be formed. This thread may now be broke off from the rod, and a new one may be again drawn out as before, by the assistance of the other glass rod.

The small ball is now to be separated from the thread of glass; this is easily effected by the sharp edge of a piece of flint. The ball should be placed in a groove of paper, and another piece of paper be held over it, to prevent the ball from flying about and being lost. A quantity of globules ought to be prepared in this manner; they are then to be cleaned, and afterwards placed in the cavities of the tripoli, by means of a delicate pair of nippers. The globules are now to be melted a second time, in order to render them completely spherical; for this purpose, bring one of the cavities near the extremity of the flame, directing this towards the tripoli, which must be first heated; the cavity is then to be lowered, so that the flame may touch the glass, which, when it is red hot, will assume a perfect globular form; it must then be removed from the flame, and laid by; when cold, it should be cleaned, by rubbing between two pieces of white paper. Let it now be set in a brass cap, to try whether the figure be perfect. If the object is not well defined, the globule must be thrown away. Though, if it be large, it may be exposed two or three times to the

the flame. When a large globule is forming, it should be gently agitated by shaking the tripoli, which will prevent it's becoming flat on one side. By attending to these directions, the greater part of the globules will be round and fit for use. In damp weather, notwithstanding every precaution, it will often happen, that out of forty globules, four or five only will be fit for use.

Mr. Stephen Gray, of the Charter-House, having observed some irregular particles within a glass globule, and finding that they appeared distinct and prodigiously magnified when held close to his eye, concluded that if he placed a globule of water, in which there were any particles more opaque than the water, near his eye, he should see those particles distinctly and highly magnified. This idea, when realized, far exceeded his expectation. His method was, to take on a pin a small portion of water which he knew had in it some minute animalculæ; this he laid on the end of a small piece of brass wire, till there was formed somewhat more than an hemisphere of water; on applying it then to the eye, he found the animalculæ most enormously magnified; for those which were scarce discernible with his glass globules, with this appeared as large as ordinary sized peas. They cannot be seen by day-light, except the room be darkened, but are seen to the greatest advantage by candle-light. Montucla observes, that when any objects are inclosed within this transparent globule, the hinder part of it acts like a concave mirror, provided they be situated between that surface and the focus; and that by this means they are magnified three times and a half more than they would be in the usual way. An extempore microscope may be formed, by taking up a small drop of water on the point of a pin, and placing it over a fine hole made in a piece of metal; but as
the

the refractive power of water is less than that of glass; these globules do not magnify so much as those of the same size, which are made of glass: this was also contrived by Mr. Gray. The same ingenious author invented another water microscope, consisting of two drops of water, separated in part by a thin brass plate, but touching near the center; which were thus rendered equivalent to a double convex lens, of unequal convexities.

Dr. Hooke describes a method of using the single microscope, which seems to have a great analogy to the foregoing methods of Mr. Gray. If you are desirous (he says) of obtaining a microscope with one single refraction, and consequently capable of procuring the greatest clearness and brightness any one kind of microscope is susceptible of; spread a little of the fluid you intend to examine on a glass plate, bring this under one of your microscopic globules, then move it gently upwards, till the fluid touches the globule, to which it will soon adhere, and that so firmly, as to bear being moved a little backwards or forwards. By looking through the globule, you will then have a perfect view of the animalculæ in the drop. *

Having laid before the reader the principal improvements that have been suggested or made in the single microscope, it remains only to point out those instruments of this kind, which, from the mode in which they are fitted up, seem best adapted for general use; the peculiar advantages of which, as well as the manner of using them, will be described in the third chapter of this work.

Fig.

* Hooke's Lectures and Conjectures, p. 98.

Fig. 3. Plate VI. represents that which was used by M. Lyonnet for dissecting the *coffus*.

Fig. 1. Plate VII. B. The aquatic microscope used by Mr. Ellis for investigating the nature of coralline, and recommended by Mr. Curtis to botanists, in his *Flora Londinensis*.

Fig. 1. Plate VI. A botanical microscope, contrived by Dr. Withering.

Fig. 2. Plate VI. A botanical microscope, by Mr. B. Martin.

Fig. 5. Plate VI. The tooth and pinion microscope, which is now generally substituted in the room of Wilson's.

Fig. 8. Plate VIII. A botanical magnifier.

Fig. 7. Plate VIII. A different kind of botanical magnifier.

A COMPOUND MICROSCOPE, as it consists of two, three, or more glasses, is more easily varied, and is susceptible of greater changes in its construction, than the single microscope. The number of the lenses, of which it is formed, may be increased or diminished, their respective positions may be varied, and the form in which they are mounted be altered almost ad infinitum. But among these varieties, some will be found more deserving of attention than others; it is of these only we shall speak in this place.

The

The three first compound microscopes that attract our notice, are those of Dr. Hooke, Eustachio Divini, and Philip Bonnani. Dr. Hooke gives an account of his in the preface to his *Micrographia*, which was published in the year 1656; it was about three inches in diameter, seven long, and furnished with four draw-out tubes, by which it might be lengthened as occasion required: it had three glasses, a small object glass, a middle glass, and a deep eye glass: Dr. Hooke used all the glasses when he wanted to take in a considerable part of an object at once, as by the middle glass a number of radiating pencils were conveyed to the eye, which would otherwise have been lost: but when he wanted to examine with accuracy the small parts of any substance, he took out the middle glass, and only made use of the eye and object lenses; for the fewer the refractions are, the clearer and more bright the object appears.

An account of Eustachio Divini's microscope was read at the Royal Society, in 1668.* It consisted of an object lens, a middle glass, and two eye glasses, which were plano convex lenses, and were placed so that they touched each other in the center of their convex surfaces; by which means the glass takes in more of an object, the field is larger, the extremities of it less curved, and the magnifying power greater. The tube, in which the glasses were inclosed, was as large as a man's leg, and the eye glasses as broad as the palm of the hand. It had four several lengths; when shut up, it was sixteen inches long, and magnified the diameter of an object forty-one times; at the second length, ninety times; at the third length, one hundred and eleven times; at

* *Philos. Transf.* No. 42.

at the fourth length, one hundred and forty-three times. It does not appear that E. Divini varied the object lenses.

Philip Bonnani published an account of his two microscopes in 1698;* both were compound; the first was similar to that which Mr. Martin published as new, in his *Micrographia Nova*,† in 1712. His second was like the former, composed of three glasses, one for the eye, a middle glass, and an object lens: they were mounted in a cylindrical tube, which was placed in an horizontal position; behind the stage was a small tube, with a convex lens at each end; beyond this was a lamp; the whole capable of various adjustments, and regulated by a pinion and rack; the small tube was used to condense the light on the object, and spread it uniformly over it according to its nature, and the magnifying power that was used.

If the reader attentively considers the construction of the foregoing microscopes, and compares them with more modern ones, he will be led to think with me, that the compound microscope has received very little improvement since the time of Bonnani. Taken separately, the foregoing constructions are equal to some of the most famed modern microscopes. If their advantages are combined, they are far superior to that of M. Dellebarre, notwithstanding the pompous eulogium affixed thereto by Mess. De L'Academie Royale des Sciences.‡

C

From

* Bonnani *Observationes circa viventia*, &c.

† *Micrographia Nova*, by B. Martin, 4to.

‡ *Memoires sur les Differences de la Construction et des Effets du Microscope*, de M. L. F. Dellebarre, 1777.

From this period, to the year 1736, the microscope appears not to have received any considerable alteration, but the science itself to have been at a stand. The improvements which were making in the reflecting telescope, naturally led those who had turned their thoughts this way, to expect a similar service for microscopes on the same principles: accordingly we find two plans of this kind; the first was that of Dr. Robert Barker. This instrument is entirely the same as the reflecting telescope, excepting the distance of the two speculums, which is lengthened, in order to adapt it to those pencils of rays which enter the telescope diverging; whereas, from very distant objects, they come in a direction nearly parallel. But this was soon laid aside, not only as it was more difficult to manage; but also because it was unfit for any but very small or transparent objects: for the object being between the speculum and the image, would, if it were large and opaque, prevent a due reflection of light on the object.

The second was contrived by Dr. Smith.* In this there were two reflecting mirrors, one concave, and the other convex; the image was viewed by a lens. This microscope, though far from being executed in the best manner, performed, says Dr. Smith, very well, so that he did not doubt but what it would have excelled others, if it had been properly finished.

As some years are more favorable to the fruits of the earth, so also some periods are more favorable to particular sciences, being rich in discovery, and cultivated with ardor. Thus, in the year

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1738,

* Dr. Smith's Optics, Remarks, p. 94.

1738, Mr. Lieburkuhn's invention of the solar microscope was communicated to the public: the vast magnifying power which was obtained by this instrument, the colossal grandeur with which it exhibited the minima of nature, the pleasure which arose from being able to display the same object to a number of observers at the same time, by affording a new source of rational amusement, increased the number of microscopic observers, who were further stimulated to the same pursuits by Mr. Trembley's famous discovery of the polype: the wonderful properties of this little animal, together with the works of Mr. Trembley, Baker, and my father, revived the reputation of this instrument. *

Every optician now exercised his talents in improving (as he called it) the microscope; in other words, in varying it's construction, and rendering it different from that sold by his neighbour. Their principal object seemed to be, only to subdivide the instrument, and make it lie in as small a compass as possible; by which means, they not only rendered it complex, and troublesome in use, but lost sight also of the extensive field, great light, and other excellent properties of the more ancient instruments; and in some measure, shut themselves out from further improvements on the microscope. Every mechanical instrument is susceptible of almost infinite combinations and changes, which are attended with their relative advantages and disadvantages: thus, what is gained in power, is lost in time; "he that loves to be confined to a small house, must lose the benefit of air and exercise."

* Trembley *Memoires sur les Polypes*. Baker's *Microscope made Easy*; Attempt towards an History of the Polype; Employment for the Microscope. Adams's *Micrographia Illustrata*. Joblot's *Observations d'Histoire Naturelle*.

The microscope, nearly at the same period, gave rise to M. Buffon's famous system of organic molecules, and M. Needham's incomprehensible ideas concerning a vegetative force and the vitality of matter. M. Buffon has dressed up his system with all the charms of eloquence, presenting it to the mind in the most agreeable and lively colours, exerting the depths of erudition in the most interesting and seducing manner, to establish his hypothesis, making us almost ready to adopt it against the dictates of reason, and the evidence of facts. But whether this great man was misled by the warmth of his imagination, his attachment to a favorite system, or the use of imperfect instruments, it appears but too evident, that he was not acquainted with the objects whose nature he attempted to investigate; and it is probable, that he never saw * those which he supposed he was describing, continually confounding the animalculæ produced from the putrifying decomposition of animal substances, with the spermatic animalculæ, although they are two kinds of beings, differing in form and nature; so that the beautiful fabric attempted to be raised on his hypothesis, vanishes before the light of truth and well conducted experiments.

After this period, the mind, either satisfied with the discoveries already made, (which will be particularly described hereafter) or tired by it's own exertions, sought for repose in other pursuits; so that for several years this instrument was again, in some measure,

* Porro Buffonius, ut cum illustribus viri venia dicam omnino non videtur, vermiculos seminales vidisse. Diuturnitas enim vitæ quam suis corpusculis tribuit, ostendit non esse nostra animalcula (id est, spermatica) quibus brevis et paucarum horarum vita est. Haller Physiol. tom. 7.

sure, laid aside. In 1770, Dr. Hill * published a treatise, in which he endeavours to explain the construction of timber by the microscope, and shew the number, the nature, and office of it's several parts, their various arrangements and proportions in the different kinds; and point out a way of judging, from the structure of trees, the uses they will best serve in the affairs of life. So important a subject soon revived the ardor for microscopic pursuits, which seems to have been increasing ever since. About the same time, my father contrived an instrument for cutting the transverse sections of wood, in order that the texture thereof might be rendered more visible in the microscope, and consequently be better understood; this instrument was afterwards improved by Mr. Cumming. Another instrument for the same purpose, more certain in it's effects, and more easily managed, is represented in fig. 1, plate 9; it will be described in one of the following chapters. Dr. Hooke and Mr. Cuffance now endeavoured to bring back the microscope nearer to the old standard, to increase the field by the multiplication of the eye glasses, and to augment the light on the object, by condensing lenses; and in this they happily succeeded: Mr. Cuffance was unrivalled in his dexterity in preparing, and accuracy in cutting thin transverse sections of wood.

In 1771, my father published a fourth edition of his *Micrographia*, in which he described the principal inventions then in use; particularly a contrivance of his own, for applying the solar microscope to the camera obscura, and illuminating it at night by
a lamp.

* Dr. Hill on the Construction of Timber.

a lamp, by which means a picture of microscopic objects might be exhibited in winter evenings.

It appears *from the testimony of M. *Æpinus*, that M. *Lieburkuhn* had considerably improved the solar microscope, by adapting it to view opaque objects. This contrivance was by some means lost. The knowledge, however, that such an effect had been produced, led *Æpinus* to attend to the subject himself, in which he in some measure succeeded, and would, no doubt, have brought it to perfection, if he had increased the size of his illuminating mirror. Some further improvements were made on this instrument by M. *Ziehr*; but the most perfect instrument of the kind, is that of Mr. B. *Martin*, who published an account of it in the year 1774.† The common solar microscope does not shew the surface of any object, whereas the opaque solar microscope not only magnifies the object, but exhibits on a screen an expanded picture of it's surface, with all it's colours, in a most beautiful manner.

About the year 1774, I invented the improved lucernal microscope; this instrument does not in the least fatigue the eye; it shews all opaque objects in a most beautiful manner; and transparent objects may be examined by it in various ways, so that no part of an object is left unexplored; and the outlines of all may be taken with ease, even by those who are most unskilled in drawing.

M. L.

* *Priestley's Hist. of Optics*, p. 743.

† *Martin's Description and Use of an Opaque Solar Microscope*.

M. L. F. Dellebarre published an account of his microscope in the year 1777. It does not appear from this, that it was superior in any respect to those that were then made in England, but was inferior in others; for those published by my father in 1771, possessed all the advantages of Dellebarre's in a higher degree, except that of changing the eye glasses.

In 1784, M. *Æpinus* published a description of what he termed new-invented microscopes, in a letter to the Academie des Sciences de St. Peterburg; * they are nothing more than an application of the acromatic perspective to microscopic purposes. Now it has been long known to every one who is the least versed in optics, that any telescope is easily converted into a microscope, by removing the object glass to a greater distance from the eye glasses; and that the distance of the image varies with the distance of the object from the focus, and is magnified more, as it's distance from the object is greater: the same telescope may, therefore, be successively turned into a microscope, with different magnifying powers. Mr. Martin had also shewn, in his description and use of a polydynamic microscope, how easily the small acromatic perspective may be applied to this purpose. Botanists might find some advantage in attending to this instrument; it would assist them in discovering small plants at a distance, and thus often save them from the thorns of the hedge, and the dirt of a ditch.

Fig. 1, Plate III. represents the improved lucernal microscope.

Fig.

* Description des Nouveaux Microscopes, inventes par M. *Æpinus*.

Fig. 1, Plate V. represents a solar opaque microscope.

Fig. 4, Plate VI. is a picture of the common solar microscope.

Fig. 3, Plate IV. is what is usually called Culpeper's, or the three pillared microscope.

Fig. 1, Plate IV. the improved double and single microscope.

Fig. 2, Plate IV. the best double constructed microscope.

Fig. 1, Plate VII. A. the common double constructed microscope.

Fig. 3, Plate VIII. a microscopic telescope, or convenient portable apparatus for a traveller.

We cannot conclude this chapter better than with the following observations on the microscope. We are indebted to it for many discoveries in natural history; but let us not suppose, that the Creator intended to hide these objects from our observation. It is true, this instrument discovers to us as it were a new creation, new series of animals, new forests of vegetables; but he who gave being to these, gave us an understanding capable of inventing means to assist our organs in the discovery of their hidden beauties. He gave us eyes adapted to enlarge our ideas, and capable of comprehending a universe at one view, and consequently incapable of discerning those minute beings, with which he has peopled every atom of the universe. But then he gave properties and qualities to matter of a particular kind, by which it would procure us this advantage, and at the same time elevated the under-

understanding from one degree of knowledge to another, till it was able to discover these assistances for our sight.

It is thus we should consider the discoveries made by those instruments, which have received their birth from an exertion of our faculties. It is to the same power, who created the objects of our admiration, that we are ultimately to refer the means of discovering them. Let no one, therefore, accuse us of prying deeper into the wonders of nature, than was intended for us. There is nothing we discover by their assistance, which is not a fresh source of praise; and it does not appear, that our faculties can be better employed, than in finding means to investigate the works of God.

From a partial consideration of these things, we are very apt to criticise what we ought to admire; to look upon as useless what perhaps we should own to be of infinite advantage to us, did we see a little farther; to be peevish where we ought to give thanks; and at the same time, to ridicule those who employ their time and thoughts in examining what we were, i. e. some of us most assuredly were, created and appointed to study. In short, we are too apt to treat the Almighty worse than a rational man would treat a good mechanic, whose works he would either thoroughly examine, or be ashamed to find any fault with them. This is the effect of a partial consideration of nature; but he who has candor of mind, and leisure to look farther, will be inclined to cry out:

How wond'rous is this scene! where all is form'd
With number, weight, and measure! all design'd.

D

For

For some great end ! where not alone the plant
 Of stately growth ; the herb of glorious hue,
 Or food-full substance ! not the laboring steed,
 The herd, and flock that feed us ; not the mine
 That yields us stores for elegance and use ;
 The sea that loads our table, and conveys
 The wanderer man from clime to clime, with all
 Those rolling spheres, that from on high shed down
 Their kindly influence ; not these alone,
 Which strike ev'n eyes incurious, but each moss,
 Each shell, each crawling insect, holds a rank
 Important in the plan of Him, who fram'd
 This scale of beings ; holds a rank, which lost
 Would break the chain, and leave behind a gap
 Which nature's self would rue. Almighty Being,
 Cause and support of all things, can I view
 These objects of my wonder ; can I feel
 These fine sensations, and not think of thee ?
 Thou who dost thro' th' eternal round of time,
 Dost thro' th' immensity of space exist
 Alone, shalt thou alone excluded be
 From this thy universe ? Shall feeble man
 Think it beneath his proud philosophy
 To call for thy assistance, and pretend
 To frame a world, who cannot frame a clod ?—
 Not to know thee, is not to know ourselves—
 Is to know nothing—nothing worth the care
 Of man's exalted spirit :—all becomes,
 Without thy ray divine, one dreary gloom,
 Where lurk the monsters of phantastic brains,

Order

Order bereft of thought, uncaus'd effects,
 Fate freely acting, and unerring chance.
 Where meanless matter to a chaos sinks,
 Or something lower still, for without thee
 It crumbles into atoms void of force,
 Void of resistance—it eludes our thought.
 Where laws eternal to the varying code
 Of self-love dwindle. Interest, passion, whim,
 Take place of right, and wrong, the golden chain
 Of beings melts away, and the mind's eye
 Sees nothing but the present. All beyond
 Is visionary guesses—is dream—is death.*

* Stillingfleet's Miscellaneous Tracts.



C H A P. II.

OF VISION, OF THE OPTICAL EFFECT OF MICROSCOPES,
AND OF THE MANNER OF ESTIMATING THEIR MAG-
NIFYING POWERS.

THE progress that has been made in the science of optics, in the last and present century, particularly by Sir Isaac Newton, may with propriety be ranked among the greatest acquisitions of human knowledge. And Mess. Delaval and Herschel have shewn by their discoveries, that the boundaries of this science may be considerably enlarged.

The rays of light, which minister to the sense of sight, are the most wonderful and astonishing part of the inanimate creation; of which we shall soon be convinced, if we consider their extreme minuteness, their inconceivable velocity, the regular variety of colours they exhibit, the invariable laws according to which they are acted upon by other substances, in their reflections, inflections, and refractions, without the least change of their original properties; and the facility with which they pervade bodies of the greatest density and closest texture, without resistance, without crowding or disturbing each other. These, I believe, will be deemed sufficient proofs of the wonderful nature of these rays; without adding, that it is by a peculiar modification of them, that we are indebted for the advantages we obtain by the microscope.

The

The science of optics, which explains and treats of many of the properties of these rays of light, is deduced from experiments, on which all philosophers are agreed. It is impossible to give an adequate idea of the nature of vision, without a knowledge of these experiments, and the mathematical reasoning grounded upon them; but as to do this would alone fill a large volume, I shall only endeavour to render some of the more general principles clear, that the reader, who is unacquainted with the science of optics, may nevertheless be enabled to comprehend the nature of vision by the microscope. Some of the most important of these principles may be deduced from the following very interesting experiment.

Darken a room, and let the light be admitted therein only by a small hole; then, if the weather is fine, you will see on the wall, which is facing the hole, a picture of all those exterior objects which are opposite thereto, with all their colours, though these will be but faintly seen. The image of the objects that are stationary, as trees, houses, &c. will appear fixed; while the images of those that are in motion, will be seen to move. The image of every object will appear inverted, because the rays cross each other in passing through the small hole. If the sun shines on the hole, we shall see a luminous ray proceed in a strait line, and terminate on the wall. If the eye is placed in this ray, it will be in a right line with the hole and the sun: it is the same with every other object which is painted on the wall. The images of the objects exhibited on the same plane, are smaller in proportion as the objects are further from the hole.

Many

Many and important are the inferences which may be deduced from the foregoing experiment, among which are the following:

1. That light flows in a right line.
2. That a luminous point may be seen from all those places to which a straight line can be drawn from the point, without meeting with any obstacle; and consequently
3. That a luminous point, by some unknown power, sends forth rays of light in all directions, and is the center of a sphere of light, which extends indefinitely on all sides; and if we conceive some of these rays to be intercepted by a plane, then is the luminous point the summit of a pyramid, whose body is formed by the rays, and its base by the intercepting plane.—The image of the surface of an object, which is painted on the wall, is also the base of a pyramid of light, the apex of which is the hole; the rays which form this pyramid, by crossing at the hole, form another, similar and opposite to this, of which the hole is also the summit, and the surface of the object the base.
4. That an object is visible, because all its points are radiant points.
5. That the particles of light are indefinitely small; for the rays, which proceed from the points of all the objects opposite to the hole, pass through it, though extremely small, without embarrassing or confounding each other.

6. That

6. That every ray of light carries with it the image of the object from which it was emitted.

The nature of vision in the eye, may be imperfectly illustrated by the experiment of the darkened room; the pupil of the eye being considered as the hole through which the rays of light pass, and cross each other, to paint on the retina, at the bottom of the eye, the inverted images of all those objects which are exposed to the sight, so that the diameter of the images of the same object are greater, in proportion to the angles formed at the pupil, by the crossing rays which proceed from the extremities of the object; that is, the diameter of the image is greater, in proportion as the distance is less; or, in other words, the apparent magnitude of an object is in some degree measured by the angle under which it is seen, and this angle increases or diminishes, according as the object is nearer to, or further from the eye; and consequently, the less the distance is between the eye and the object, the larger the latter will appear.

From hence it follows, that the apparent diameter of an object seen by the naked eye, may be magnified in any proportion we please; for as the apparent diameter is increased, in proportion as the distance from the eye is lessened, we have only to lessen the distance of the object from the eye, in order to increase the apparent diameter thereof.* Thus, suppose there is an object, AB, Plate I. Fig. 1, which to an eye at E subtends or appears under the angle AEB, we may magnify the apparent diameter in what proportion we please, by bringing our eye nearer to it. If, for instance, we would magnify it in the proportion of FG

to

* Rutherford's System of Natural Philosophy, p. 330.

to AB ; that is, if we would see the object under an angle as large as $FE G$, or would make it appear the same length that an object as long as FG would appear, it may be done by coming nearer to the object. For the apparent diameter is as the distance inversely; therefore, if CD is as much less than CE , as FG is greater than AB , by bringing the eye nearer to the object in the proportion of CD to ED , the apparent diameter will be magnified in the proportion of FG to AB ; so that the object AB , to the eye at D , will appear as long as an object FG would appear to the eye at E . In the same manner, we might shew, that the apparent diameter of an object, when seen by the naked eye, may be infinite. For since the apparent diameter is reciprocally as the distance of the eye, when the distance of the eye is nothing, or when the eye is close to the object at C , the apparent diameter will be the reciprocal of nothing, or infinite.

There is, however, one great inconvenience in thus magnifying an object, without the help of glasses, by placing the eye nearer to it. The inconvenience is, that we cannot see an object distinctly, unless the eye is about five or six inches from it; therefore, if we bring it nearer to our eye than five or six inches, however it may be magnified, it will be seen confusedly. Upon this account, the greatest apparent magnitude of an object that we are used to, is the apparent magnitude, when the eye is about five or six inches from it: and we never place an object much within that distance; because, though it might be magnified by this means, yet the confusion would prevent our deriving any advantage from seeing it so large. The size of an object seems extraordinary, when viewed through a convex lens; not because it is impossible to make it appear of the same size to the naked eye,

but because at the distance from the eye which would be necessary for this purpose, it would appear exceedingly confused; for which reason, we never bring our eye so near to it, and consequently, as we have not been accustomed to see the object of this size, it appears an extraordinary one.

On account of the extreme minuteness of the atoms of light, it is clear, a single ray, or even a small number of rays, cannot make a sensible impression on the organ of sight, whose fibres are very gross, when compared to these atoms; it is necessary, therefore, that a great number should proceed from the surface of an object, to render it visible. But as the rays of light, which proceed from an object, are continually diverging, different methods have been contrived, either of uniting them in a given point, or of separating them at pleasure: the manner of doing this, is the subject of dioptrics and catoptrics.

By the help of glasses, we unite in the same sensible point a great number of rays, proceeding from one point of an object; and as each ray carries with it the image of the point from whence it proceeded, all the rays united must form an image of the object from whence they were emitted. This image is brighter, in proportion as there are more rays united; and more distinct, in proportion as the order, in which they proceeded, is better preserved in their union. This may be rendered evident; for, if a white and polished plane is placed where the union is formed, we shall see the image of the object painted in all its colours on this plane; which image will be brighter, if all adventitious light is excluded from the plane on which it is received.

The point of union of the rays of light, formed by means of a glass lens, &c. is called the FOCUS.

Now, as each ray carries with it the image of the object from whence it proceeded, it follows, that if those rays, after intersecting each other, and having formed an image at their intersection, are again united by a refraction or reflection, they will form a new image, and that repeatedly, as long as their order is not confounded or disturbed.

It follows also, that when the progress of the luminous ray is under consideration, we may look on the image as the object, and the object as the image; and consider the second image, as if it had been produced by the first as an object, and so on.

In order to gain a clear idea of the wonderful effects produced by glasses, we must proceed to say something of the principles of refraction.

Any body, which is so constituted as to yield a passage to the rays of light, is called a MEDIUM. Air, water, glass, &c. are mediums of light. If any medium affords an easy passage to the rays of light, it is called a RARE MEDIUM; but if it does not afford an easy passage to these rays, it is called a DENSE MEDIUM.

Let Z, Fig. 2, Plate I. be a rare medium, and Y a dense one; and let them be separated by the plane surface GH. Let IK be a perpendicular to it, and cutting it in C.

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With the center C, and any distance, let a circle be described. Then let AC be a ray of light, falling upon the dense medium. This ray, if nothing prevented, would go forward to L; but because the medium Y is supposed to be denser than Z, it will be bent downward toward the perpendicular IK, and describe the line CB.

The ray AC is called the INCIDENT RAY; and the ray CB, the REFRACTED RAY.

The angle ACI is called the ANGLE OF INCIDENCE, and the angle BCK is called the ANGLE OF REFRACTION.

If from the point A, upon the right line CI, there be let fall the perpendicular AD, that line is called the sine of the angle of incidence.

In the same manner, if from the point B, upon the right line IK, there be let fall the perpendicular BE, that line will be the sine of the angle of refraction.

The sines of the angles are the measures of the refractions; and this measure is constant; that is, whatever is the sine of the angle of incidence, it will be in a constant proportion to the sine of the angle of refraction, when the mediums continue the same. A general idea of refraction may be formed from the following experiments.

Let ABCD, Fig. 3, Plate I. represent a vessel so placed, with respect to the candle E, that the shadow of the side AC may fall

at D. Suppose the vessel to be now filled with water, and the shadow will withdraw to d; the ray of light, instead of proceeding to D, being refracted or bent to d. And there is no doubt but that an eye, placed at d, would see the candle at e, in the direction of the refracted ray d A. This is also confirmed by the following pleasing experiment.

Lay a shilling, or any piece of money, at the bottom of a basin; then withdraw from the basin, till you lose sight of the shilling; fill the basin nearly with water, and the shilling will be seen very plainly, though you are at the same distance from it.

Experiment 3. Place a stick over a basin which is filled with water; then reflect the sun's rays, so that they may fall perpendicularly on the surface of the water; the shadow of the stick will fall on the same place, whether the vessel be empty or full.

What has been said of water, may be applied to any transparent medium, only the power of refraction is greater in some than in others. It is from this wonderful property, that we derive all the curious effects of glass, which make it the subject of optics. It is to this we owe the powers of the microscope and the telescope.

To produce these effects, pieces of glass are formed into given figures, which, when so formed, are called lenses. The six under-mentioned figures, are those which are most in use for optical purposes.

1. A PLANE GLASS, one that is flat on each side, and of an equal thickness throughout. F, Fig. 13, Plate I.

2. A DOUBLE CONVEX GLASS, one that is more elevated towards the middle than the edge. B, Fig. 13, Plate I.

3. A DOUBLE CONCAVE is hollow on both sides, or thinner in the middle than at the edges. D, Fig. 13, Plate I.

4. A PLANO CONVEX, flat on one side, and convex on the other. A, Fig. 13, Plate I.

5. A PLANO CONCAVE, flat on one side, and concave on the other. C, Fig. 13, Plate I.

6. A MENISCUS, convex on one side, concave on the other. E, Fig. 13, Plate I.

It has been already observed, that light proceeds invariably from a luminous body, in straight lines, without the least deviation; but if it happen to pass from one medium to another, it always leaves the direction it had before, and assumes a new one. After having taken this new direction, it proceeds in a straight line, till it meets with a different medium, which again turns it out of its course.

A ray of light, passing obliquely through a plane glass, will go out in the same direction it entered, though not precisely in the same line. The ray CD, Fig. 4, Plate I. falling obliquely upon the surface of the plane glass AB, will be refracted towards
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the glass in the direction DE; but when it comes to E, it will be as much refracted the contrary way. If the ray of light had fallen perpendicularly on the surface of the plane glass, it would have passed through it in a straight line, and not have been refracted at all.

If parallel rays of light, as a b c d e f g, Fig. 6, Plate I. fall directly upon a convex lens A B, they will be so bent, as to unite in a point C behind it. For the ray d D, which falls perpendicularly upon the middle of the glass, will go through it without suffering any refraction: but those which go through the sides of the lens, falling obliquely on its surface, will be so bent, as to meet the central ray at C. The further the ray a is from the axis of the lens, the more obliquely it will fall upon it. The rays a b c d e f g will be so refracted, as to meet or be collected in the point F, called the principal focus, whose distance, in a double convex lens, is equal to the radius or semi-diameter of the sphere of the convexity of the lens. All the rays cross the middle ray at C, and then diverge from it to the contrary side, in the same manner as they were before converged.

If another lens, of the same convexity, as A B, Fig. 6, Plate I. be placed in the rays, and at the same distance from the focus, it will refract them, so that after going out of it, they will all be parallel again, and go on in the same manner as they came to the first glass A B, but on the contrary sides of the middle ray.

The rays diverge from any radiant point, as from a principal focus: therefore, if a candle be placed at C, in the focus of the convex lens A B, Fig. 6, Plate I. the rays diverging from it will

be so refracted by the lens, that after going out of it, they will become parallel. If the candle be placed nearer the lens than it's focal distance, the rays will diverge more or less, as the candle is more or less distant from the focus.

If any object, *A B*, Fig. 7, Plate I. be placed beyond the focus of the convex lens *E F*, some of the rays which flow from every point of the object, on the side next the glass, will fall upon it, and after passing through it, they will be converged into as many points on the opposite side of the glass; for the rays *a b*, which flow from the point *A*, will converge into *ab*, and meet at *C*. The rays *c d*, flowing from the point *C*, will be converged into *cd*, and meet at *g*; and the rays which flow from *B*, will meet each other again at *D*; and so of the rays which flow from any of the intermediate points: for there will be as many focal points formed, as there are radiant points in the object, and consequently they will paint on a sheet of paper, or any other light-coloured body, placed at *D g e*, an inverted image of the object. If the object is brought nearer the lens, the picture will be formed further off. If it be placed at the principal focus, the rays will go out parallel, and consequently form no picture behind the glass.

The human eye is so constituted, that it can only have distinct vision, when the rays which fall on it are parallel, or nearly so; because the retina, on which the image is painted, is placed in the focus of the crystalline humor, which performs the office of a lens in collecting rays, and forming the image in the bottom of the eye.

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The picture, formed by a convex lens, is either larger or less than the object, in proportion as it's distance from the lens is greater or less than it's distance from the object.

As an object becomes perceptible to us, by means of the image thereof which is formed on the retina, it will, therefore, be seen in that direction, in which the rays enter the eye to form the image, and will always be found in the line, in which the axis of a pencil of rays flowing from it enter the eye. We from hence acquire a habit of judging the object to be situated in that line. Note; as the mind is unacquainted with the refraction the rays suffer before they enter the eye, it judges them to be in the line produced back, in which the axis of a pencil of rays flowing from it is situated, and not in that in which it was before the refraction.

If the rays, therefore, that proceed from an object, are refracted and reflected several times before they enter the eye, and these refractions, or reflections, change considerably the original direction of the rays which proceed from the object; it is clear, that it will not be seen in that line, which would come straight from it to the eye; but it will be seen in the direction of those rays which enter the eye, and form the image thereof on it.

We perceive the presence and figure of objects, by the impression each respective image makes on the retina; the mind, in consequence of these impressions, forms conclusions concerning the size, position, and motion of the object. It must however be observed, that these conclusions are often rectified or changed by the mind, in consequence of the effects of more habitual impressions. For example; there is a certain distance, at which,
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in the general business of life, we are accustomed to see objects: now, though the measure of the image of these objects changes considerably when they move from, or approach nearer to us, yet we do not perceive that their size is much altered: but beyond this distance, we find the objects appear to be diminished, or increased, in proportion as they are more or less distant from us.

For instance, if I place my eye successively at two, at four, and at six feet from the same person, the dimensions of the image on the retina will be nearly in the proportion of 1, of $\frac{1}{2}$, of $\frac{1}{3}$, and consequently they should appear to be diminished in the same proportion; but we do not perceive this diminution, because the mind has rectified the impression received on the retina. To prove this, we need only consider, that if we see a person at 120 feet distance, he will not appear so strikingly small, as if the same person should be viewed from the top of a tower, or other building, 120 feet high, a situation to which we had not been accustomed.

From hence, also, it is clear, that when we place a glass between the object and the eye, which from it's figure changes the direction of the rays of light from the object, this object ought not to be judged as if it were placed at the ordinary reach of the sight, in which case we judge of it's size more by habit than by the dimensions of the images formed on the retina: but it must be estimated by the size of the image in the eye, or by the angle formed at the eye, by the two rays which come from the extremity of the object.

If the image of an object, formed after refraction, is greater or less than the angle formed at the eye, by the rays proceeding from the extremities of the object itself, the object will appear also proportionably enlarged or diminished; so that if the eye approaches to, or removes from, the last image, the object will appear to increase or diminish, though the eye should in reality remove from it in one case, or approach towards it in the other; because the image takes place of the object, and is considered instead of it.

The apparent distance of an object from the eye, is not measured by the real distance from the last image; for, as the apparent distance is estimated principally by the ideas we have of their size, it follows, that when we see objects, whose images are increased or diminished by refraction, we naturally judge them to be nearer or further from the eye, in proportion to the size thereof, when compared to that with which we are acquainted. The apparent distance of an object is considerably affected by the brightness, distinctness, and magnitude thereof. Now as these circumstances are, in a certain degree, altered by the refraction of the rays, in their passing through different mediums, they will also, in some measure, affect the estimation of the apparent distance.

In the theory of vision, it is necessary to be cautious not to confound the organs of vision with the being that perceives, or with the perceptive faculty. The eye is not that which sees, it is only the organ by which we see. A man cannot see the satellites of Jupiter but by a telescope. Does he conclude from this, that it is the telescope that sees those stars? By no means; such a conclusion would be absurd. It is no less absurd to conclude,

that it is the eye that sees. The telescope is an artificial organ of sight, but it sees not. The eye is a natural organ of sight, by which we see; but the natural organ sees as little as the artificial.

The eye is a machine, most admirably contrived for refracting the rays of light, and forming a distinct picture of objects upon the retina; but it sees neither the object nor the picture. It can form the picture after it is taken out of the head, but no vision ensues. Even when it is in its proper place, and perfectly sound, it is well known, that an obstruction in the optic nerve takes away vision, though the eye has performed all that belongs to it.*

For useless was this textur'd † wonder made,
 Were nature, beauteous object! undisplayed;
 Those both in vain, the object and the sight,
 Wrapt from the radiance of revealing light;
 As vain the bright illuminating beam,
 Unwafted by the medium's airy stream:
 Yet vain the textur'd eye, and object fair,
 The sunny lustre, and continuous air;
 Annull'd and blank this grand illustrious scene,
 All, all its grace and lifeless glories vain;
 Till from th' ETERNAL sprung this effluent soul,
 Form'd to inspect, and comprehend the whole.‡

F 2

OF

* Reid on the Intellectual Powers of Man, p. 78.

† The eye.

‡ Brooke's Universal Beauty, p. 88.

OF THE SINGLE MICROSCOPE.

The single microscope renders minute objects visible, by means of a small glass globule, or convex lens, of a short focus. Let E Y, Fig. 11, Plate I. represent the eye; and O B, a small object, situated very near to it, consequently the angle of it's apparent magnitude very large. Let the convex lens R S be interposed between the eye and the object, so that the distance between it and the object may be equal to the focal length; and the rays which diverge from the object, and pass through the lens, will afterwards proceed, and consequently enter the eye parallel: after which, they will be converged, and form an inverted picture on the retina, and the object will be clearly seen; though, if removed to the distance of six inches, it's smallness would render it invisible.

When the lens is not held close to the eye, the object is somewhat more magnified; because the pencils, which pass at a distance from the center of the lens, are refracted inward toward the axis, and consequently seem to come from points more remote from the center of the object, as may be seen in Fig. 12, Plate I. where the pencils which proceed from O and B are refracted inwards, and seem to come from the point i and m.

Fig. 8, Plate I. may, perhaps, give the reader a still clearer view, why a convex lens increases the angle of vision. Without a lens, as F G, the eye at A would see the dart B C under the angle b A c; but the rays B F and C G from the extremities of the dart in passing through the lens, are refracted to the eye in the directions f A and G a, which causes the dart to be seen under the

the much larger angle DAE (the same as the angle fAg). And therefore, the dart BC will appear so much magnified, as to extend in length from D to E .

The object, when thus seen distinctly, by means of the small lens, appears to be magnified nearly in the proportion which the focal distance of the glass bears to the distance of the objects, when viewed by the naked eye.

To explain this further, place the eye close to the glass, that as much of the object may be seen at one view as is possible; then remove the object to and fro, till it appears perfectly distinct, and well defined; now remove the lens, and substitute in its place a thin plate, with a very small hole in it, and the object will appear as distinct, and as much magnified, as with the lens, though not quite so bright; and it appears as much more magnified in this case, than it does when viewed with the naked eye, as the distance of the object from the hole, or lens, is less than the distance at which it may be seen distinctly with the naked eye.

From hence we see, that the whole effect of the lens is to render the object distinct, which it does by assisting the eye to increase the refraction of the rays in each pencil; and that the apparent magnitude is entirely owing to the object being seen so much nearer the eye than it could be viewed without it.

Single microscopes magnify the diameter of the object, * as we have already shewn, in the proportion of the focal distance (to the limits.

* Cyclopaedia art. microscope.

limits of distinct vision with the naked eye) to eight inches. For example, if the semi-diameter of a lens, equally convex on both sides, be half an inch, which is also equal to its focal distance, we shall have as $\frac{1}{2}$ is to 8, so is 1 to 16; that is, the diameter of the object in the proportion of sixteen to one. 2. As the distance of eight inches is always the same, it follows, that by how much the focal distance is smaller, there will be a greater difference between it and the eight inches; and consequently, the diameter of the object will be so much the more magnified, in proportion as the lenses are segments of smaller spheres. 3. If the object be placed in the focus of a glass globule or sphere, and the eye be behind it in the focus, the object will be seen distinct in an erect situation, and magnified as to its diameter, in the proportion of $\frac{3}{4}$ of the diameter of the globule to eight inches; thus suppose the diameter of the sphere to be $\frac{1}{10}$ of an inch, then $\frac{3}{4}$ of this will be equal to $\frac{3}{40}$; consequently, the real diameter of the object to the apparent one, as $\frac{3}{40}$ to 8, or as 3 to 320, or as 1 to 160 nearly.

OF THE DOUBLE OR COMPOUND MICROSCOPE.

In the compound microscope, the image is viewed instead of the object, which image is magnified by a single lens, as the object is in a single microscope. It consists of an object lens, L N, Fig. 5, Plate I. and an eye glass F G. The object O B is placed a little further from the lens than its principal focal distance, so that the pencils of rays proceeding from the different points of the object through the lens, may converge to their respective foci, and form an inverted image of the object at P Q; which image is viewed by the eye through the eye glass F G, which is
so

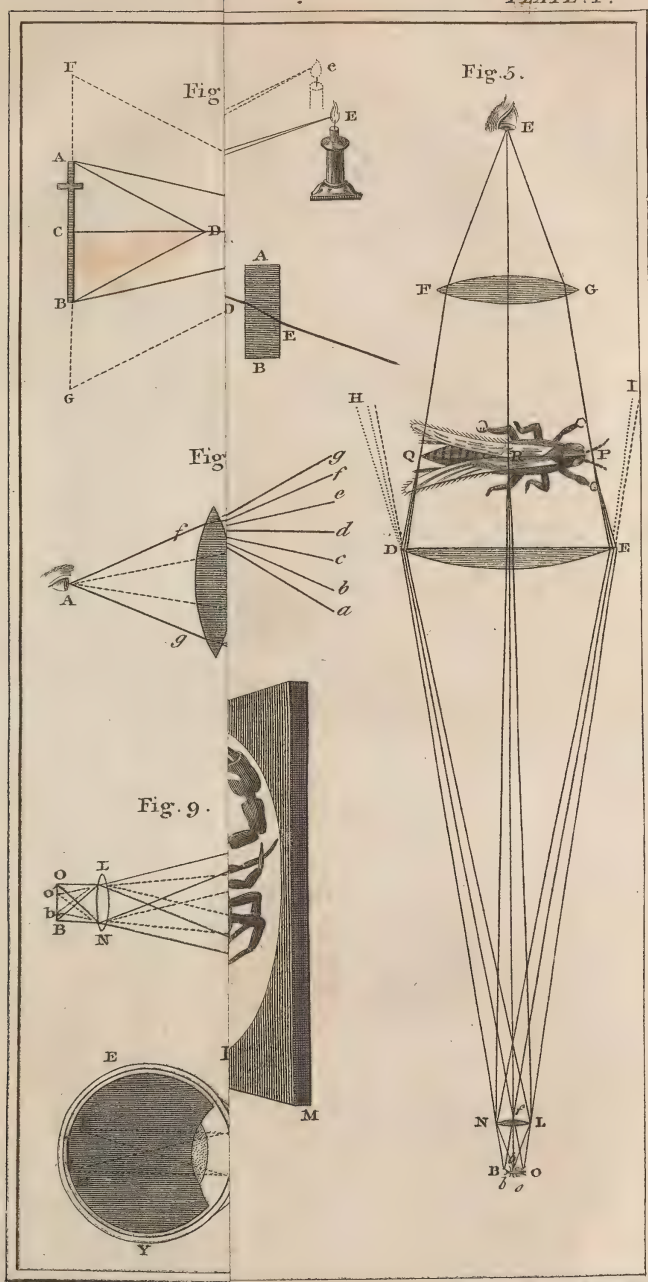
so placed, that the image may be in it's focus on one side, and the eye at the same distance on the other. The rays of each pencil will be parallel, after passing out of the glass, till they reach the eye at E, where they will begin to converge by the refractive powers of the humours; and after having crossed each other in the pupil, and passed through the chrystalline and vitreous humours, they will be collected in points on the retina, and form a large inverted image thereon.

It will be easy, from what has been already explained, to understand the reason of the magnifying power of a compound microscope. The object is magnified upon two accounts; first, because if we viewed the image with the naked eye, it would appear as much larger than the object, as the image is really larger than it, or as the distance fR is greater than the distance fb ; and secondly, because this picture is again magnified by the eye glass, upon the principle explained in the foregoing article on vision, by single microscopes.

But it is to be noted, that the image formed in the focus of a lens, as is the case in the compound microscope, differs from the real object in a very essential particular; that is to say, the light being emitted from the object in every direction, renders it visible to an eye placed in any position; but the points of the image formed by a lens, emitting no more than a small conical body of rays, which arrives from the glass, can be visible only when the eye is situate within it's confine. Thus the pencil, which emanates from o in the object, and is converged by the lens to M , proceeds afterwards diverging towards H , and therefore, never arrives at the lens FG , nor enters the eye at E . But the
pencils

pencils which proceed from the points *o* and *b*, will be received on the lens *F G*, and by it carried parallel to the eye; consequently, the correspondent points of the image *Q P* will be visible; and those which are situate farther out towards *H* and *I*, will not be seen. This quantity of the image *Q P*, or visible area, is called the field of view.

Hence it appears, that if the image be large, a very small part of it will be visible; because the pencils of rays will for the most part fall without the eye glass *F G*. And it is likewise plain, that a remedy which would cause the pencils, which proceed from the extremes *O* and *B* of the object, to arrive at the eye, will render a greater part of it visible; or, in other words, enlarge the field of view. This is effected by the interposition of a broad lens *D E* (Fig. 5.) of a proper curvature, at a small distance from the focal image. For, by that means, the pencil *DM*, which would otherwise have proceeded towards *H*, is refracted to the eye, as delineated in the figure, and the mind conceives from thence the existence of a radiant point at *Q*, from which the rays last proceeded. In like manner, and by a parity of reason, the other extreme of the image is seen at *P*, and the intermediate points are also rendered visible. On these considerations it is, that compound microscopes are usually made to consist of an object lens *L N*, by which the image is formed, enlarged, and inverted; an amplifying lens *D E*, by which the field of view is enlarged, and an eye glass or lens, by means of which the eye is allowed to approach very near, and consequently to view the image under a very great angle of apparent magnitude. It is now customary to combine two or more lenses together at the eye glass, in the manner of Eustachio Divini and M. Joblot; by which



T. Aldine del.

J. Kneller sc.

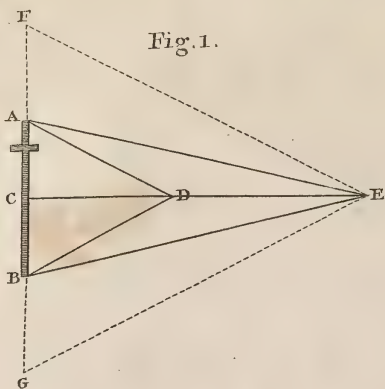


Fig. 1.

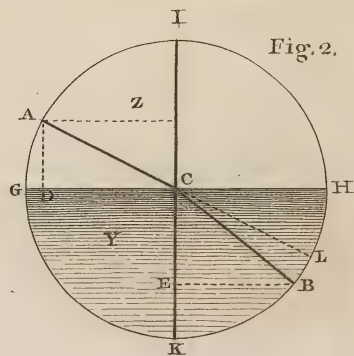


Fig. 2.

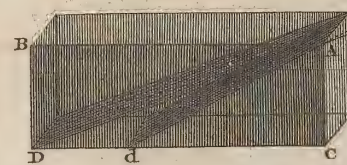


Fig. 3.

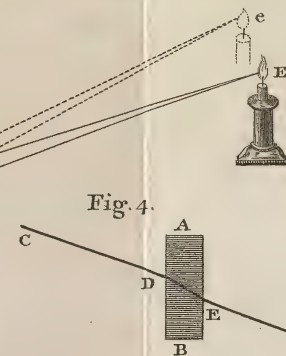


Fig. 4.

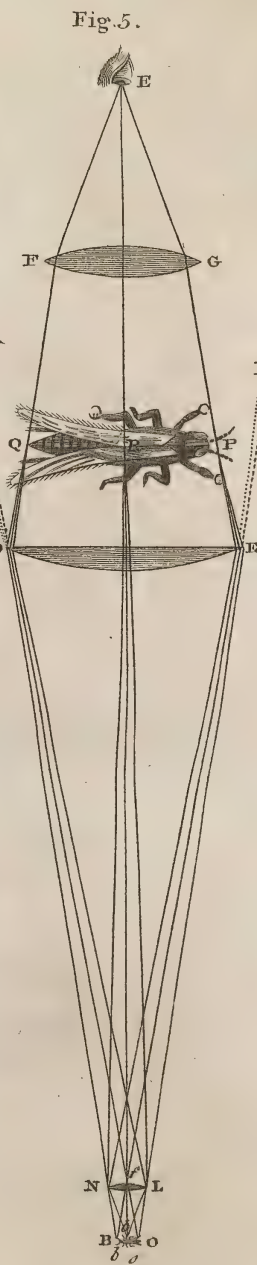


Fig. 5.

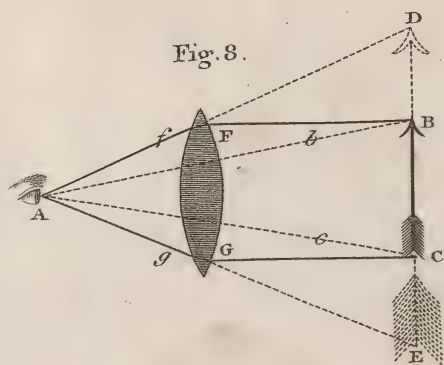


Fig. 8.

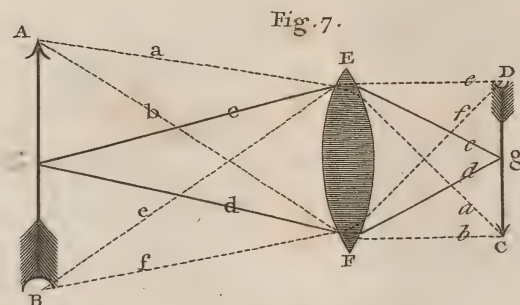


Fig. 7.

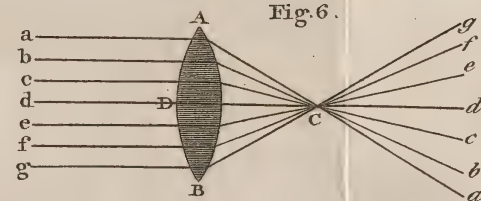


Fig. 6.

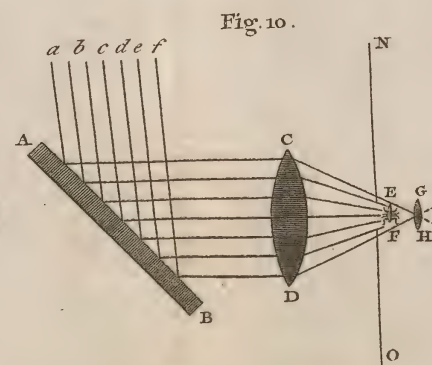


Fig. 10.

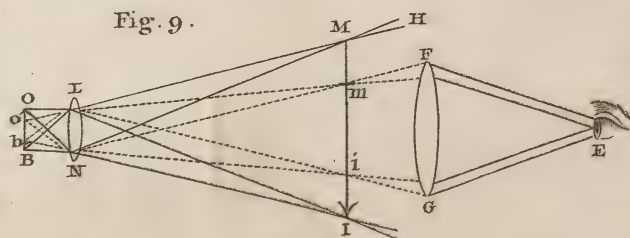


Fig. 9.

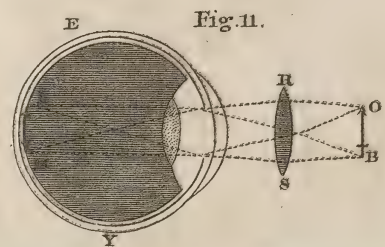


Fig. 11.

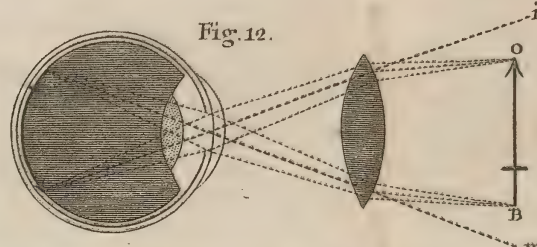


Fig. 12.

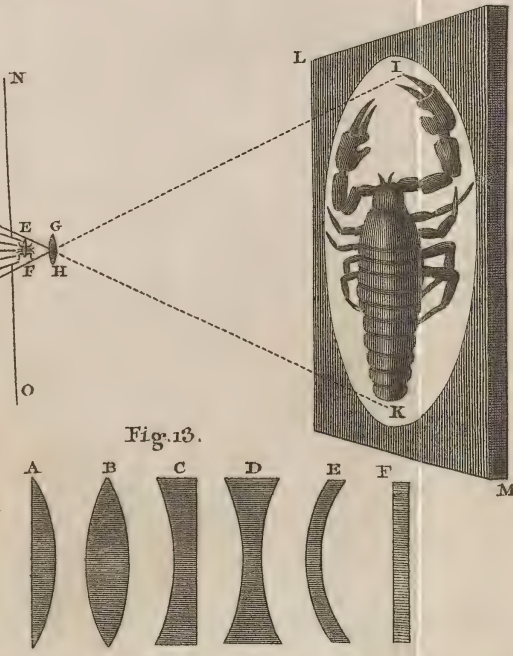


Fig. 13.



which means, the aberration of light from the figure is in some measure corrected, and the apparent field increased.

OF THE SOLAR MICROSCOPE.

In this instrument, the image of the object is thrown upon a screen in a darkened room. It may be considered under two distinct heads: 1st, the mirror and lens, which are intended to reflect the light of the sun upon the object; and 2dly, that part which constitutes the microscope, or which produces the magnified image of the object, Fig. 10, Plate I. Let NO represent the side of a darkened chamber, GH a small convex lens, fixed opposite to a perforation in the side NO, AB a plane mirror, or looking-glass, placed without the room to reflect the solar rays on the lens CD, by which they are converged and concentrated on the object fixed at EF.

2. The object being thus illuminated, the ray which proceeds from E will be converged by the lens GH to a focus K, on the screen LM; and the ray which comes from F will be converged to I, and the intermediate points will be delineated between I and K; thus forming a picture, which will be as much larger than the object, in proportion as the distance of the screen exceeds that of the image from the object.

From what has been said, it appears plainly, the advantages we gain by microscopes are derived, first, from their magnifying power, by which the eye is enabled to view more distinctly the parts of minute objects: secondly, that by their assistance, more light is thrown into the pupil of the eye, than is done with-

out them. The advantages procured by the magnifying power, would be exceedingly circumscribed, if they were not accompanied by the latter : for if the same quantity of light is diffused over a much larger surface, it's force is proportionably diminished; and therefore the object, though magnified, will be dark and obscure. Thus, suppose the diameter of the object to be enlarged ten times, and consequently the surface one hundred times, yet, if the focal distance of the glass was eight inches, (provided this was possible) and it's diameter only about the size of the pupil of the eye, the object would appear one hundred times more obscure when viewed through the glass, than when it was seen by the naked eye; and this even on the supposition, that the glass transmitted all the light which fell upon it, which no glass can do. But if the glass was only four inches focal distance, and it's diameter remained as before, the inconvenience would be vastly diminished; because the glass could be placed twice as near the object as before, and would consequently receive four times as many rays as in the former case, and we should therefore see it much brighter than before. By going on thus, diminishing the focal distance of the glass, and keeping it's diameter as large as possible, we shall perceive the object proportionably magnified, and yet remain bright and distinct. Though this is the case in theory, yet there is a limit in optical instruments, which is soon arrived at, but which cannot be passed. This arises from the following circumstances.*

1. The quantity of light lost in passing through the glass.

2. The

* Encyclopedia Britannica, vol. viii. p. 5635.

2. The diminution in the diameter of the glass or lens itself, by which it receives only a small quantity of rays.

3. The extreme shortness of the focal distance of great magnifiers, whereby the free access of the light to the object we wish to view is impeded, and consequently the reflection of the light from it is weakened.

4. The aberration of the rays, occasioned by their different refrangibility.

To make this more clear, let us suppose a lens made of such dull kind of glass, that it transmits only one half the light that falls upon it. It is evident, that supposing this lens to be of four inches focus, and to magnify the diameter of the object twice, and its own breadth equal to that of the pupil of the eye, the object will be four times magnified in surface, but only half as bright as if it was seen by the naked eye at the usual distance; for the light which falls upon the eye from the object at eight inches distance, and likewise the surface of the object in its natural size, being both represented by 1, the surface of the magnified object will be 4, and the light which makes it visible only 2; because though the glass receives four times as much light as the naked eye does at the usual distance of distinct vision, yet one half is lost in passing through the glass. The inconvenience, in this respect, can only be removed so far as it is possible to increase the transparency of the glass, that it may transmit nearly all the rays which fall upon it; and how far this can be done, has not been yet ascertained.

The second obstacle to the perfection of microscopic glasses, is the small size of great magnifiers; by which means, notwithstanding their near approach to the object, they receive a smaller quantity of light than might be expected. Thus, suppose a glass of only one-tenth of an inch focal distance, such a glass would increase the visible diameter eighty times, and the surface 6400 times. If the breadth of the glass could at the same time be preserved as great as the pupil of the eye, which we shall suppose one-tenth of an inch, the object would appear magnified 6400 times, and every part would be as bright as it appears to the naked eye. But if we suppose the lens to be only $\frac{1}{16}$ of an inch diameter, it will then only receive $\frac{1}{4}$ of the light which would otherwise have fallen upon it; therefore, instead of communicating to the magnified object a quantity of light equal to 6400, it would communicate an illumination suited only to 1600, and the magnified object would appear four times as dim as it does to the naked eye. This inconvenience can, however, be in a great degree removed, by throwing a much larger quantity of light on the object. Various methods of effecting this purpose will be pointed out in the course of the work.

The third obstacle arises from the shortness of the focal distance in large magnifiers; this inconvenience can, like the former, be remedied in some degree by artificial means of accumulating light; but still the eye is so strained, as it must be brought nearer the glass than it can well bear, which in some measure supercedes the use of very deep lenses, or such as are capable of magnifying beyond a certain degree.

The

The fourth obstacle which arises from the different refrangibility of the rays of light, and which frequently causes such deviations from truth in the appearance of things, that many have imagined themselves to have made surprizing discoveries, and have communicated them as such to the world; when, in fact, they have been only optical deceptions, owing to the unequal refraction of the rays. In telescopes, this error has been happily corrected by Mr. Dollond's valuable discovery of achromatic glasses; but how far this invention is applicable to the improvement of microscopes, has not yet been ascertained; and indeed there is some reason for supposing, they cannot be successfully applied to them; so that this obstacle remains yet to be remedied, before microscopes can be said to have received their ultimate degree of perfection.

OF THE MAGNIFYING POWERS OF THE MICROSCOPE.

We have already treated of the apparent magnitude of objects, and shewn that they are measured by the angles under which they are seen, and that this angle is greater or smaller, according as the object is nearer to, or further from, the eye; and consequently, the less the distance at which it can be viewed, the larger it will appear: but from the limits of natural vision, the naked eye cannot distinguish an object that is very near to it; yet, when assisted by a convex lens, distinct vision is obtained, however short the focus of the lens, and consequently, how near soever the object is to the eye; and the shorter the focus of the lens is, the greater will be the magnifying power thereof. From these considerations, it will not be difficult to estimate the magnifying power of any lens used as a single microscope; for this

this will be in the same proportion that the limits of natural sight bear to the focus of the lens. If, for instance, the convex lens is of one inch focus, and the natural sight of eight inches, an object seen through that lens will have its diameter apparently increased eight times; but as the object is increased in every direction, we must square this apparent diameter, to know how much the object is really magnified; and thus multiplying 8 by 8, we find the superficies is magnified 64 times.

From these principles, the following general rule for ascertaining the magnifying power of single lenses, is deduced. Place a small thin transparent object on the stage of the microscope, adjust the lens till the object appears perfectly distinct, then measure the distance accurately between the lens and the object, reduce the measure thus found to the hundredths of an inch, and calculate how many times this measure is contained in eight inches, first reducing the eight inches into hundredths, which will give you the number of times the diameter of the object is magnified; which number multiplied into itself, or squared, gives the apparent superficial magnitude of the object.

As only one side of an object can be viewed at a time, it is sufficient, in general, to know how much the surface thereof is magnified: but when it is necessary to know how many minute objects are contained in a larger, as for instance, how many given animalcula are contained in the bulk of a grain of sand, then we must cube the first number, by which means we shall obtain the solidity or magnified bulk.

The

The foregoing rule has been also applied to estimate the magnifying power of the compound microscope. To this application, Mr. Magny, in the "*Journal d'Economie pour les mois d'Aout 1753*," has made several objections: one or two of these I shall just mention: the first is the difficulty of ascertaining with accuracy the precise focus of a small lens; the second is the want of a fixed or known measure, with which to compare the focus when ascertained. These considerations, though apparently trifling, will be found of importance in the calculations which are relative to deep magnifiers. To this it may be further added, that the same standard or fixed measure cannot be assumed for a short-sighted, that is, used for a well-constituted eye. To obviate these difficulties, and some errors in the methods which were recommended by Mess. Baker and Needham, Mr. Magny offers the following

PROPOSITION.

All convex lenses, of whatsoever focus, double the apparent diameter of an object, provided that the object is at the focus of the glass on one side, and the eye is at the same distance, or on the focus of the glass, at the opposite side.

EXPERIMENT.

Take a double convex lens, of six or eight inches focus, and fix it as at A, Fig. 1, (Plate II. A,) into the piece A, which is fixed perpendicular to the rule F G, and may be slid along it by means of its socket: the rule is divided into inches and parts. Paste a piece of white paper, two or three tenths of an inch broad, and

three inches long, on the board D; draw three lines with ink on this piece of paper, so as to divide it into four equal parts, taking care that the middle of the paper corresponds with the center of the lens. There is also a sliding eye-piece, which is represented at e.

Take this apparatus into the darkest part of the room, but opposite to the window; direct the glass towards any remarkable and distant object which is out of doors, and move the sliding piece B, until the image of the object on the paper is sharp and clear. The distance between the face of the paper and the lens, (which is shewn on the side of the rule by the divisions thereon) is the focus of the glass; now set the eye-piece e E to the same distance on the other side of the glass, then with one eye close to the sight at e, look at the magnified image of the lines, and with the other eye at the lines themselves: the image, seen by means of the glass, and expressed in the figure by the dotted lines, will be double the breadth of the same object seen by the natural eye. This will be found to be true, whatsoever is the focus of the lens with which the experiment is made.

This experiment is rendered more simple to those who are not accustomed to observe with both eyes at the same time, by making use of half a lens, and placing the diameter perpendicular to the rule, as they may then readily view the magnified image and real object with the same glance of the eye, and thus compare them together with ease and accuracy.

Let the angle AFB, Fig. 3, Plate II. A, represent that which is formed at the naked eye, by the rays of light which pass from the extremities

extremities of the object, and unite at the eye in the point F. The angle DFE is formed of the two rays, which at first proceeded parallel to each other from the extremities of the object, but that were afterwards so refracted, or bent, by passing through the glass, as to unite at it's focal point F. CO is equal to the focal distance of the lens on the side next the object, CF equal thereto on the side next the eye, FO the distance of the eye.

From the allowed principles of optics, it is evident, that the object would appear double the size to the eye at C, that it would to the eye when placed at F; because the distance FO is double the distance CO. We have only to prove then, that the angle ACB is equal to the angle IFK, in order to establish the proposition.

The optical axis is perpendicular to the glass and the surface of the object. The rays AI, BK, which flow from the points AB, are parallel to each other, and perpendicular to the glass, till they arrive at it; they are then refracted, and proceed to F, where they form the triangle IFK, resting on the base IK: now as CF is equal to CO, and IK is equal to AB, the two triangles ACB IFK are similar, and consequently the angle at C is equal to the angle F. If the visual rays are continued to the surface of the object, they will form the triangle DFE, equiangular to the triangle ABC; and therefore, as CO is to AB, so is FD to DE; and consequently, the apparent diameter of the object seen through the lens, is double the size that it is when viewed by the naked eye. No notice is here taken of the double refraction of the rays, as it does not affect the demonstration.

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If

If you advance towards M, half the focal distance, the apparent diameter will be only increased one-third. If, on the contrary, the point of sight is lengthened to double the distance of it's focus, then the magnified diameter will appear to be three times that of the real object. Mr. Magny concludes from hence, that there is an impropriety in estimating the magnifying power of the eye glass of compound microscopes, by seeing how often it's focus is contained in eight or ten inches; and to obviate these defects, he recommends two methods to be used, which reciprocally confirm each other.

The first and most simple method to find how much any compound microscope magnifies an object, is the same which is described by Dr. Hooke in his *Micrographia*, and is as follows: place an accurate scale, which is divided into very minute parts of an inch, on the stage of your microscope; adjust the microscope, till these divisions appear distinct; then observe with the other eye how many divisions of a rule, similarly divided and held at the stage, are included in one of the magnified divisions: for if one division, as seen with one eye through the microscope, extends to thirty divisions on the rule, which is seen by the naked eye, it is evident, that the diameter of the object is increased or magnified thirty times.

For this purpose, we often use a small black ebony rule, (see Fig. 4, Plate II. A,) three or four tenths of an inch broad, and about seven inches long; at each inch is fixed a piece of ivory, the first inch is entirely of ivory, and subdivided into ten equal parts.

2. A piece of glass, Fig. 2, fixed in a brass or ivory slider; on the diameter of this are drawn two parallel lines, about three-tenths of an inch long; each tenth being divided, one into three, the second into four, the third into five parts. To use this, place the glass, Fig. 2, on the middle of the stage, and the rule, Fig. 4, on one side, but parallel to it; then look into the microscope with one eye, keeping the other open, and observe how many parts one-tenth of a line in the microscope takes in upon the parts of the rule seen by the naked eye. For instance, suppose with a fourth magnifier, that one-tenth of an inch magnified answers in length to forty tenths or parts on the rule, when seen by the naked eye, then this magnifier increases the diameter of the object forty times.

This mode of actual admeasurement is, without doubt, the most simple that can be used; by it we comprehend, as it were, at one glance, the different effects of combined glasses; it saves the trouble, and avoids the obscurity that attends the usual modes of calculation; but many persons find it exceedingly difficult to adopt this method, because they have not been accustomed to observe with both eyes at once. We shall therefore proceed to describe another method, which has not this inconvenience.

OF THE NEEDLE MICROMETER.

Fig. 8, Plate II. A, represents this micrometer. The first of this kind was made by my father, and was described by him in his *Micrographia Illustrata*. It consists of a screw, which has fifty threads to an inch; this screw carries an index, which points to the divisions on a circular plate, which is fixed at right angles

to the axis of the screw. The revolutions of the screw are counted on a scale, which is an inch divided into fifty parts; the index to these divisions is, a flower de luce marked upon the slider, which carries the needle point across the field of the microscope. Every revolution of the micrometer screw measures $\frac{1}{50}$ part of an inch, which is again subdivided by means of the divisions on the circular plate, as this is divided into twenty equal parts, over which the index passes at every revolution of the screw; by which means, we obtain with ease the measure of one thousandth part of an inch: for 50, the number of threads on the screw in one inch, being multiplied by 20 the divisions on the circular plate, are equal to 1000; so that each division on the circular plate shews, that the needle has either advanced or receded one thousandth part of an inch.

To place this micrometer on the body of the microscope, open the circular part F K H, Fig. 8, Plate II. A, by taking out the screw G, throw back the semicircle F K which moves upon a joint at K, then turn the sliding tube of the body of the microscope, so that the small holes which are in both tubes may exactly coincide, and let the needle g of the micrometer have a free passage through them; after this, screw it fast upon the body by the screw G.

The needle will now traverse the field of the microscope, and measure the length and breadth of the image of any object that is applied to it. But further assistance must be had, in order to measure the object itself, which is a subject of real importance; for though we have ascertained the power of the microscope, and know that it is so many thousand times, yet this will be of little assistance.

assistance towards ascertaining an accurate idea of it's real size; for our ideas of bulk being formed by the comparison of one object with another, we can only judge of that of any particular body, by comparing it with another whose size is known: the same thing is necessary, in order to form an estimate by the microscope; therefore, to ascertain the real measure of the object, we must make the point of the needle pass over the image of a known part of an inch placed on the stage, and write down the revolutions made by the screw, while the needle passed over the image of this known measure; by which means, we ascertain the number of revolutions on the screw, which are adequate to a real and known measure on the stage. As it requires an attentive eye to watch the motion of the needle point, as it passes over the image of a known part of an inch on the stage, we ought not to trust to one single measurement of the image, but ought to repeat it at least six times; then add the six measures thus obtained together, and divide their sum by six, or the number of trials; the quotient will be the mean of all the trials. This result is to be placed in a column of a table, next to that which contains the number of the magnifiers.

By the assistance of the sectoral scale, we obtain with ease a small part of an inch. This scale is shewn at Fig. 5, 6, 7, Plate II. A, in which, the two lines ca cb , with the side ab , form an isosceles triangle; each of the sides is two inches long, and the base one-tenth of an inch. The longer sides may be of any given length, and the base still only of one-tenth of an inch. The longer lines may be considered as the line of lines upon a sector opened to one-tenth of an inch. Hence, whatever number of equal parts ca cb are divided into, their transverse measure will
be

be such a part of one-tenth, as is expressed by their divisions. Thus, if it be divided into ten equal parts, this will divide the inch into one hundred equal parts; the first division next *c* will be equal to one hundredth part of an inch, because it is the tenth part of one-tenth of an inch. If these lines are divided into twenty equal parts, the inch will be by that means divided into two hundred equal parts. Lastly, if *ab ca* are made three inches long, and divided into one hundred equal parts, we obtain with ease the one thousandth part. The scale is represented as solid at Fig. 6, but as perforated at Fig. 5 and 7; so that the light passes through the aperture, when the sectoral part is placed on the stage.

To use this scale, first, fix the micrometer, Fig. 8, Plate II. A, to the body of the microscope; then fit the sectoral scale, Fig. 7, in the stage, and adjust the microscope to its proper focus or distance from the scale, which is to be moved till the base appears in the middle of the field of view; then bring the needle point *g*, Fig. 8, (by turning the screw *L*) to touch one of the lines *ca* exactly at the point answering to 20 on the sectoral scale. The index *a* of the micrometer, Fig. 8, is to be set to the first division, and that on the dial plate to 20, which is both the beginning and end of its divisions: we are then prepared to find the magnifying power of every magnifier in the compound microscope which we are using.

Example; every thing being prepared agreeable to the foregoing directions, suppose you are desirous of ascertaining the magnifying power of the lens marked No. 4; turn the micrometer screw, until the point of the needle has passed over the magnified image

image of the tenth part of one inch; then the division, where the two indices remain, will shew how many revolutions, and parts of a revolution, the screw has made, while the needle point traversed the magnified image of the one-tenth of an inch; suppose the result to be twenty-six revolutions of the screw, and fourteen parts of another revolution, this is equal to 26 multiplied by 20, added to 14; that is, 534 thousandth parts of an inch.

The twenty-six divisions found on the strait scale of the micrometer, while the point of the needle passed over the magnified image of one-tenth part of an inch, were multiplied by 20, because the circular plate C D, Fig. 8, is divided into 20 equal parts; this produced 520; then adding the fourteen parts of the next revolution, we obtain the 534 thousandth parts of an inch, or 5 tenths and 34 hundredth parts of another tenth, which is the measure of the magnified image of one-tenth of an inch, at the aperture of the eye glasses, or at their foci. Now if we suppose the focus of the two eye glasses to be one inch, the double thereof is two inches; or if we reckon in the thousandth part of an inch, we have two thousand parts for the distance of the eye from the needle point of the micrometer. Again, if we take the distance of the image from the object at the stage at six inches, or six thousandths, and add thereto two thousand, double the distance of the focus of the eye glass, we shall have eight thousand parts of an inch for the distance of the eye from the object; and as from the proposition, page 55, we gather that the glasses double the image, we must double the number 534 found upon the micrometer, which then makes 1068: then, by the following analogy, we shall obtain the number of times the microscope

microscope magnifies the diameter of the object; say, as 240, the distance of the eye from the image of the object, is to 800, the distance of the eye from the object, so is 1068, double the measure found on the micrometer, to 3563, or the number of times the microscope magnifies the diameter of the object. By working in this manner, the magnifying power of each lens used with the compound microscope, may be easily found, though the result will be different in different compound microscopes, varying according to the combination of the lenses, their distance from the object and one another, &c.

Having discovered the magnifying power of the microscope, with the different object lenses that are used therewith, our next subject is to find out the real size of the objects themselves, and their different parts; this is easily effected, by finding how many revolutions of the micrometer-screw answer to a known measure on the sectoral scale, or other object placed on the stage; from the number thus found, a table should be constructed, expressing the value of the different revolutions of the micrometer with that object lens, by which the primary number was obtained. Similar tables must be constructed for each object lens. By a set of tables of this kind, the observer may readily find the measure of any object he is examining; for he has only to make the needle point traverse over this object, and observe the number of revolutions the screw has made in its passage, and then look into his table for the real measure which corresponds to this number of revolutions, which is the measure required.

Fig. 2.

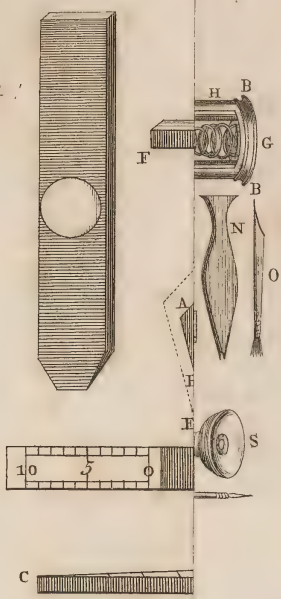


Fig. 2.

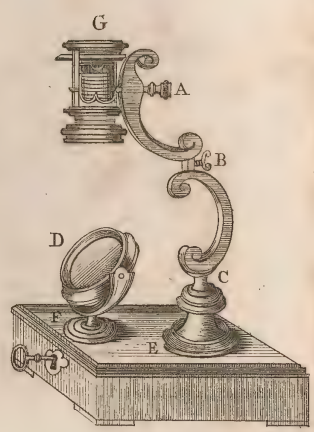
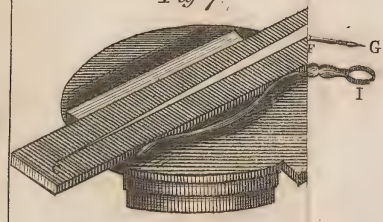
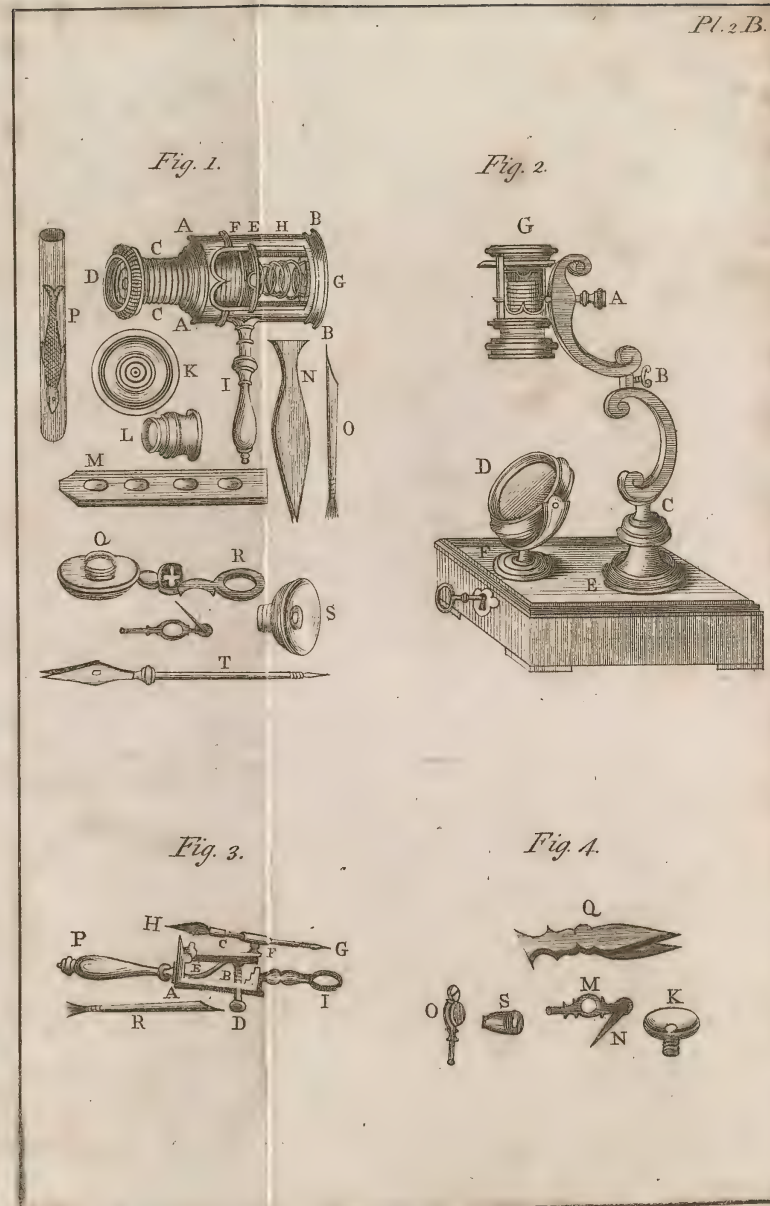
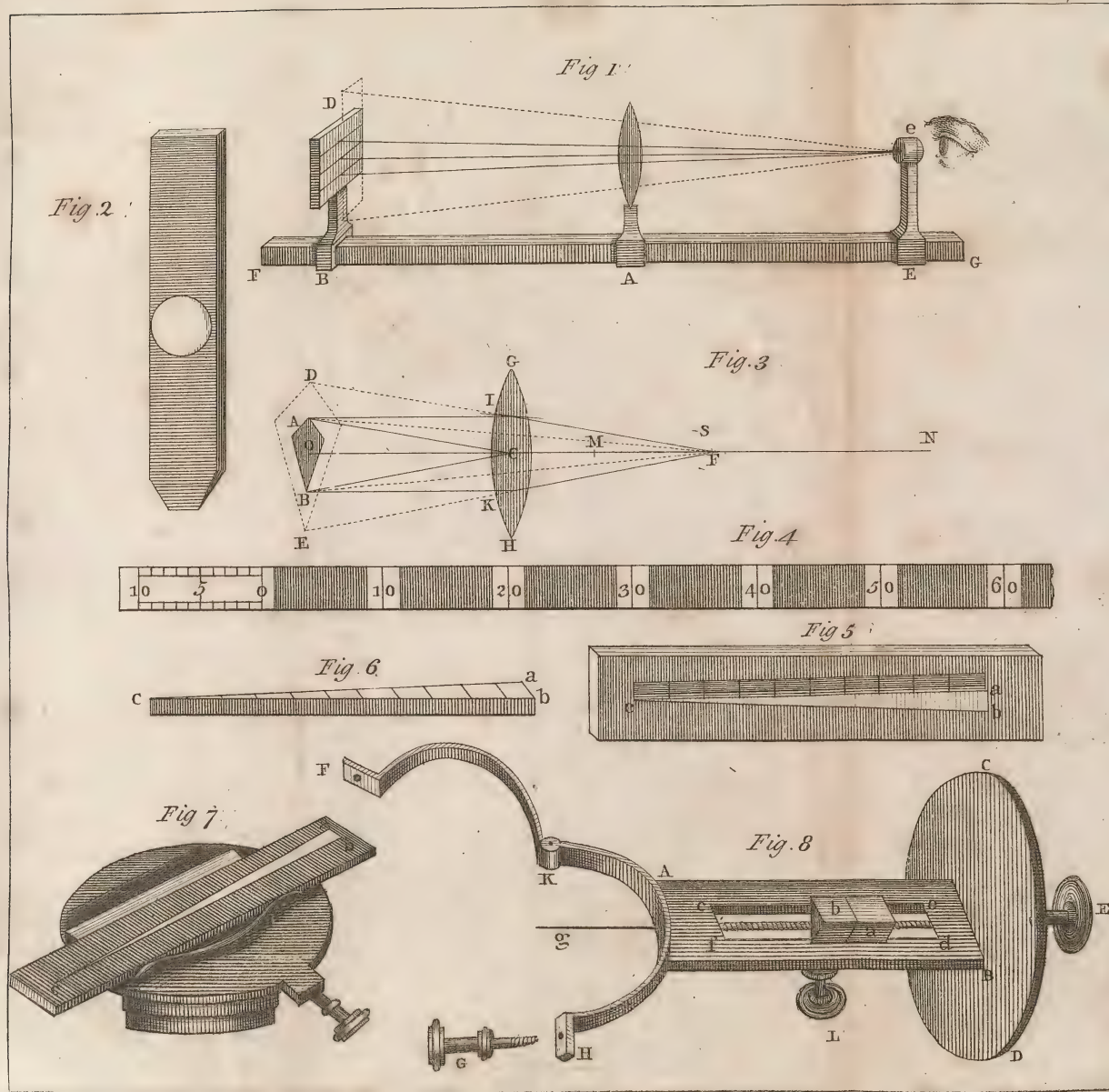


Fig. 4.



Fig. 7.







C H A P. III.

A DESCRIPTION OF THE MOST APPROVED MICROSCOPES,
AND THE METHOD OF USING THEM.

IN the preceding chapter I have endeavoured to give a comprehensive view of the theory of the microscope, and the principles on which the wonderful effects of this instrument depend. I shall now proceed to describe the various instruments themselves, their apparatus, and the most easy and ready mode of applying them to use; selecting for description those, that from some peculiar advantage in their construction, or from the reputation of the authors who have recommended and used them, are in most general use. What is said of these will, I hope, be sufficient to enable the reader to manage any other kind that may fall in his way.

DESCRIPTION OF ADAMS'S IMPROVED AND UNIVERSAL
LUCERNAL MICROSCOPE, Fig. 1, Plate III.

This microscope was originally thought of, and in part executed by my father; I have, however, so improved and altered it, both in construction and form, as to render it altogether a different instrument. The approbation it has received from the most experienced microscopic observers, as well as the great

demand I have had for them, has fully repaid my pains and expences, in bringing it to it's present state of perfection.

As the far greater part of the objects which surround us are opaque, and very few are sufficiently transparent to be examined by the common microscopes, an instrument that could be readily applied to the examination of opaque objects, has always been a desideratum. Even in the examination of transparent objects, many of the fine and more curious portions are lost, and drowned as it were in the light which must be transmitted through them; while different parts of the same object appear only as dark lines or spots, because they are so opaque, as not to permit any light to pass through them. These difficulties, as well as many more, are obviated in the lucernal microscope; by which, opaque objects, of various sizes, may be seen with ease and distinctness; the beautiful colours with which most of them are adorned, are rendered more brilliant, without changing in the least the real tint of the colour. The concave and convex parts of an object retain also their proper form.

The facility with which all opaque objects are applied to this instrument, is another considerable advantage, and almost peculiar to itself; as the texture and configuration of the more tender parts are often hurt by previous preparation, every object may be examined by this instrument, first, as opaque, and afterwards, if the texture will admit of it, as transparent.

The lucernal microscope does not in the least fatigue the eye; the object appears like nature itself, giving ease to the sight, and
pleasure

pleasure to the mind: there is also, in the use of this instrument, no occasion to shut that eye which is not directed to the object.

A further advantage peculiar to this microscope is, that by it the outlines of every object may be taken, even by those who are not accustomed to draw; while those who can draw well, will receive great assistance, and execute their work with more accuracy, and in less time than they would otherwise have been able to have performed it in. Most of the designs for this work were taken with the lucernal microscope; and, I hope, the accuracy with which they are executed, will be deemed a sufficient testimony in favour of the instrument. In this point of view, it will, I think, be found of great use to the anatomist, the botanist, the entomologist, &c. as it will enable them not only to investigate the object of their researches, but to convey to others accurate delineations of the subject they wish to describe.

By the addition of a tin lanthorn to this apparatus, transparent objects may be thrown on a screen, and exhibited at one view to a large company, as by the solar microscope.

Transparent objects may be examined with this instrument in three or four different modes; from a blaze of light almost too great for the eye to bear, to that which is perfectly easy to it.

When this instrument is fitted up in the best way, we generally send a small double and single microscope with it.

Fig. 1, Plate III represents the IMPROVED LUCERNAL MICROSCOPE, mounted to view opaque objects; ABCDE is a large mahogany

mahogany pyramidical box, which forms the body of the microscope; it is supported firmly on the brass pillar F G, by means of the socket H, and the curved piece I K.

L M N is a guide for the eye, in order to direct it in the axis of the lenses; it consists of two brass tubes, one sliding within the other, and a vertical flat piece, at the top of which is the hole for the eye. The outer tube is seen at M N, the vertical piece is represented at L M. The inner tube may be pulled out, or pushed in, to adjust it to the focus of the glasses. The vertical piece may be raised or depressed, that the hole, through which the object is to be viewed, may coincide with the center of the field of view; it is fixed by a milled screw at M, which could not be shewn in this figure.

At N is a dove-tailed piece of brass, made to receive the dove-tail at the end of the tubes M N, by which it is affixed to the wooden box A B C D E. The tubes M N may be removed from this box occasionally, for the convenience of packing it up in a less compass.

O P a small tube which carries the magnifiers.

O one of the magnifiers; it is screwed into the end of a tube, which slides within the tube P; the tube P may be unscrewed occasionally from the wooden body.

Q R S T V X a long square bar, which passes through the sockets Y Z, and carries the stage or frame that holds the objects; this bar may be moved backward or forward, in order to adjust it to the focus, by means of the pinion which is at a.

b c

b e is a handle furnished with an universal joint, for more conveniently turning the pinion. When the handle is removed, the nut, Fig. 2, may be used in it's stead.

d e is a brass bar, to support the curved piece K I, and keep the body A B firm and steady.

f g h i is the stage for opaque objects; it fits upon the bar Q R S T by means of the socket h i, and is brought nearer to, or removed further from, the magnifying lens, by turning the pinion a: the objects are placed in the front side of the stage, (which cannot be seen in this figure) between four small brass plates; the edges of two of these are seen at k l. The two upper pieces of brass are moveable; they are fixed to a plate, which is acted on by a spiral spring, that presses them down, and confines the slider with the objects; this plate, and the two upper pieces of brass, are lifted up by the small nut m.

At the lower part of the stage, there is a semicircular lump of glass n, which is designed to receive the light from the lamp, Fig. 3, and to collect and throw it on the concave mirror O, from whence it is to be reflected on the object.

The upper part, f g r s, of the opaque stage takes out, that the stage for transparent objects may be inserted in it's place.

Fig. 4, represents the stage for transparent objects; the two legs, 5 and 6, fit into the top of the under part r s h i of the stage for opaque objects; 7 is the part which confines or holds the sliders, and through which they are to be moved; 9 and 10 a brass

brass tube, which contains the lenses for condensing the light, and throwing it upon the object; there is a second tube within that, marked 9 and 10, which may be placed at different distances from the object by the pin 11.

When this stage is used as a single microscope, without any reference to the lucernal, the magnifiers, or object lenses, are to be screwed into the hole 12, and to be adjusted to a proper focus by the nut 13.

N. B. At the end A B of the wooden body, there is a slider, which is represented as partly drawn out at A; when quite taken out, three grooves will be perceived, one of which contains a board that forms the end of the box, the next contains a frame with a greyed glass, the third, or that farthest from the end A B, two large convex lenses.

OF THE LAMP.

Fig. 3, represents one of ARGAND's lamps, which are the most suitable for microscopic purposes, on account of the clearness, the intensity, and the steadiness of the light. The following account of the method of managing them, with other observations, is copied from an account given by Mr. Parker with those he sells.

The principle on which the lamp acts, consists in disposing the wick in thin parts, so that the air may come into contact with all the burning fuel, by which means, together with an increase of the current of air occasioned by rarefaction in the glass tube, the whole of the fuel is converted into flame.

The wicks are circular, and, the more readily to regulate the quantity of light, are fixed on a brass collar with a wire handle, by means of which they are raised or depressed at pleasure.

To fix the wick on, a wood mandril is contrived, which is tapered at one end, and has a groove turned at the other.

The wick has a felvage at one end, which is to be put foremost on the mandril, and moved up to the groove; then putting the groove into the collar of the wick-holder, the wick is easily pushed forward upon it.

The wick-holder and wick being put quite down in their place, the spare part of the wick should, while dry, be set alight, and suffered to burn to the edge of the tubes; this will leave it more even than by cutting, and, being black by burning, will be much easier lighted: for this reason, the black should never be quite cut off.

The lamp should be filled an hour or two before it is wanted, that the cotton may imbibe the oil and draw the better.

The lamps which have a reservoir and valve, need no other direction for filling than to do it with a proper trimming pot, carefully observing when they are full; then pulling up the valve by the point, the reservoir, being turned with the other hand, may be replaced without spilling a drop.

Those lamps which fill in the front like a bird-fountain, must be reclined on the back to fill, and this should be done gently,
that

that the oil in the burner may return into the body when so placed and filled; if, by being too full, any oil appears above the guard, only move the lamp a little, and the oil will disappear; the lamp may then be placed erect, and the oil will flow to its proper level.

The oil must be of the spermaceti-kind, commonly called chamber oil, which may generally be distinguished by its paleness, transparency, and inoffensive scent; all those oils which are of a red and brown colour, and of an offensive scent, should be carefully avoided, as their glutinous parts clog the lamp, and the impurities in such oil not being inflammable, will accumulate and remain in the form of a crust on the wick. Seal oil is nearly as pale and sweet as chamber oil; but being of a heavy sluggish quality, is not proper for lamps with fine wicks.

Whenever bad oil has been used, on changing it, the wick must also be changed, because after having imbibed the coarse particles in its capillary tubes, it will not draw up the fine oil.

To obtain the greatest degree of light, the wick should be trimmed exactly even, the flame will then be completely equal.

There will be a great advantage in keeping the lamp clean, especially the burner and air tubes; the neglect of cleanliness in lamps is too common: a candlestick is generally cleaned every time it is used, so should a lamp; and if a candlestick is not to be objected to because it does not give light after the candle is exhausted, so a lamp should not be thought ill of, if it does not give light when it wants oil or cotton; but this last has often happened, because the deficiency is less visible.

The

The glafs tubes are beft cleaned with a piece of wafh leather.

If a fountain-lamp is left partly filled with oil, it may be liable to overflow; this happens by the contraction of the air when cold, and it's expanfion by the warmth of a room, the rays of the fun, or the heat of the lamp when re-lighted: this accident may be effectually prevented by keeping the refervoir filled, the oil not being fubject to expanfion like air. On this account, thofe with a common refervoir are beft adapted for microfcopic purpofes.

TO EXAMINE OPAKE OBJECTS WITH THE LUCERNAL
MICROSCOPE.

The microfcope is reprefented as mounted, and entirely ready for this purpofe, in Fig. 1, Plate III.

To render the ufe of this inftrument eafy, it is ufually packed with as many of the parts together as poffible; it occupies on this account rather more room, but is much lefs embarrassing to the obferver, who has only three parts to put on after it is taken out of it's box, namely, the guide for the eye, the ftage, and the tube with it's magnifier.

But to be more particular, take out the wooden flide A, then lift out the cover and the grey glafs from their refpective grooves under the flide A.

Put the end N of the guide for the eye L M N into it's place, fo that it may ftand in the pofition which is reprefented in this figure.

K

Place

Place the socket, which is at the bottom of the opaque stage, on the bar QXT, so that the concave mirror o may be next the end DE of the wooden body.

Screw the tubes PO into the end DE. The magnifier you intend to use is to be screwed on the end o of these tubes.

The handle Gb, or milled nut, Fig. 2, must be placed on the square end of the pinion a.

Place the lamp lighted before the glass lump n, and the object you intend to examine between the spring plates of the stage, and the instrument is ready for use.



In all microscopes, there are two circumstances which must be particularly attended to; the modification of the light, or the proper quantity to illuminate the object; secondly, the adjustment of the instrument to the focus of the glasses and the eye of the observer. In the use of the lucernal microscope there is a third circumstance, which is, the regulation of the guide for the eye, each of which I shall consider by itself.

1. To throw the light upon the object. The flame of the lamp is to be placed rather below the center of the glass lump n, and as near it as possible; the concave mirror o must be so inclined and turned, as to receive the light from the glass lump, and reflect it thence upon the object; the best situation of the concave mirror,
and

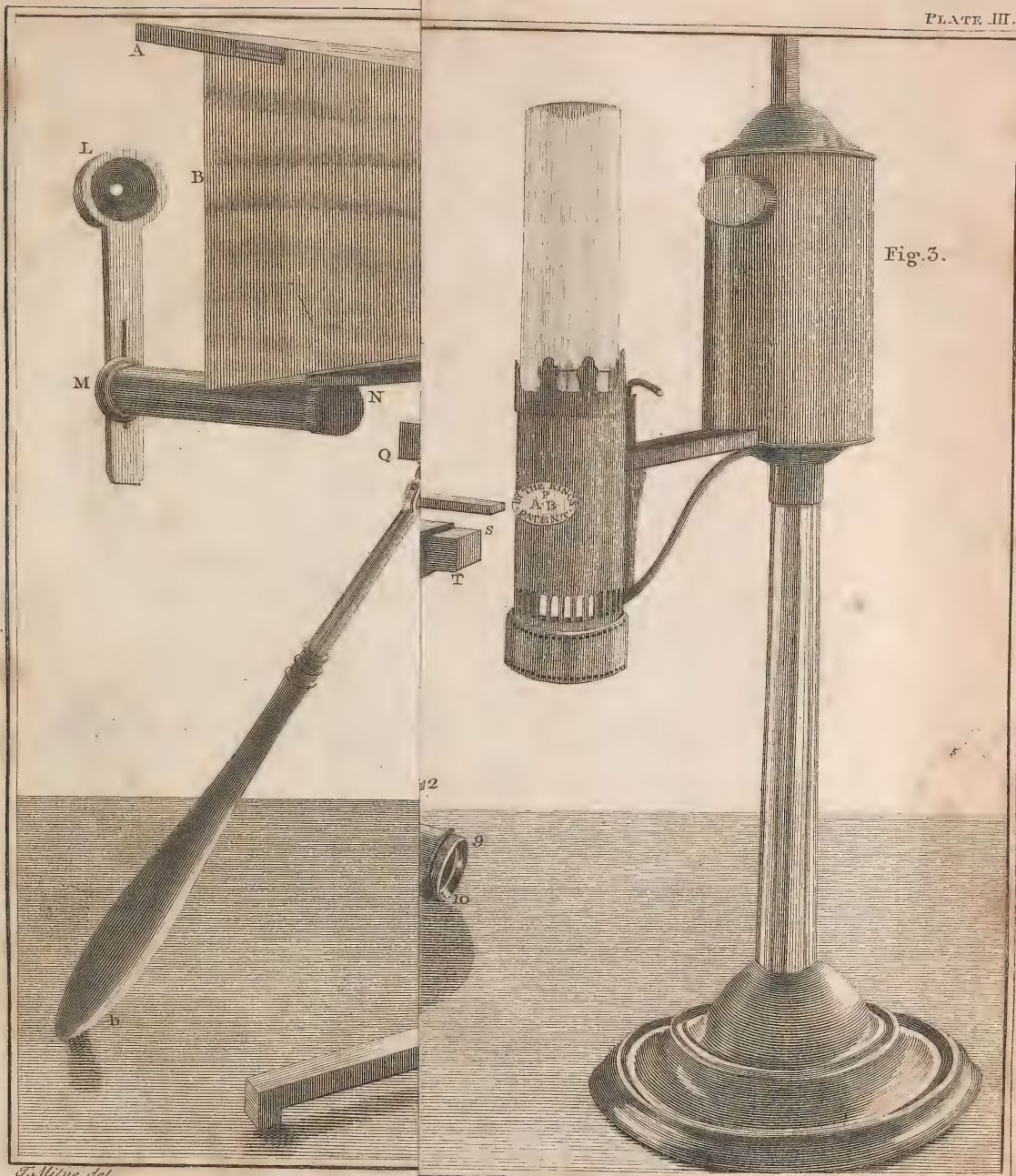


Fig. 5.

J. Moline del.

J. Lodge sculp.

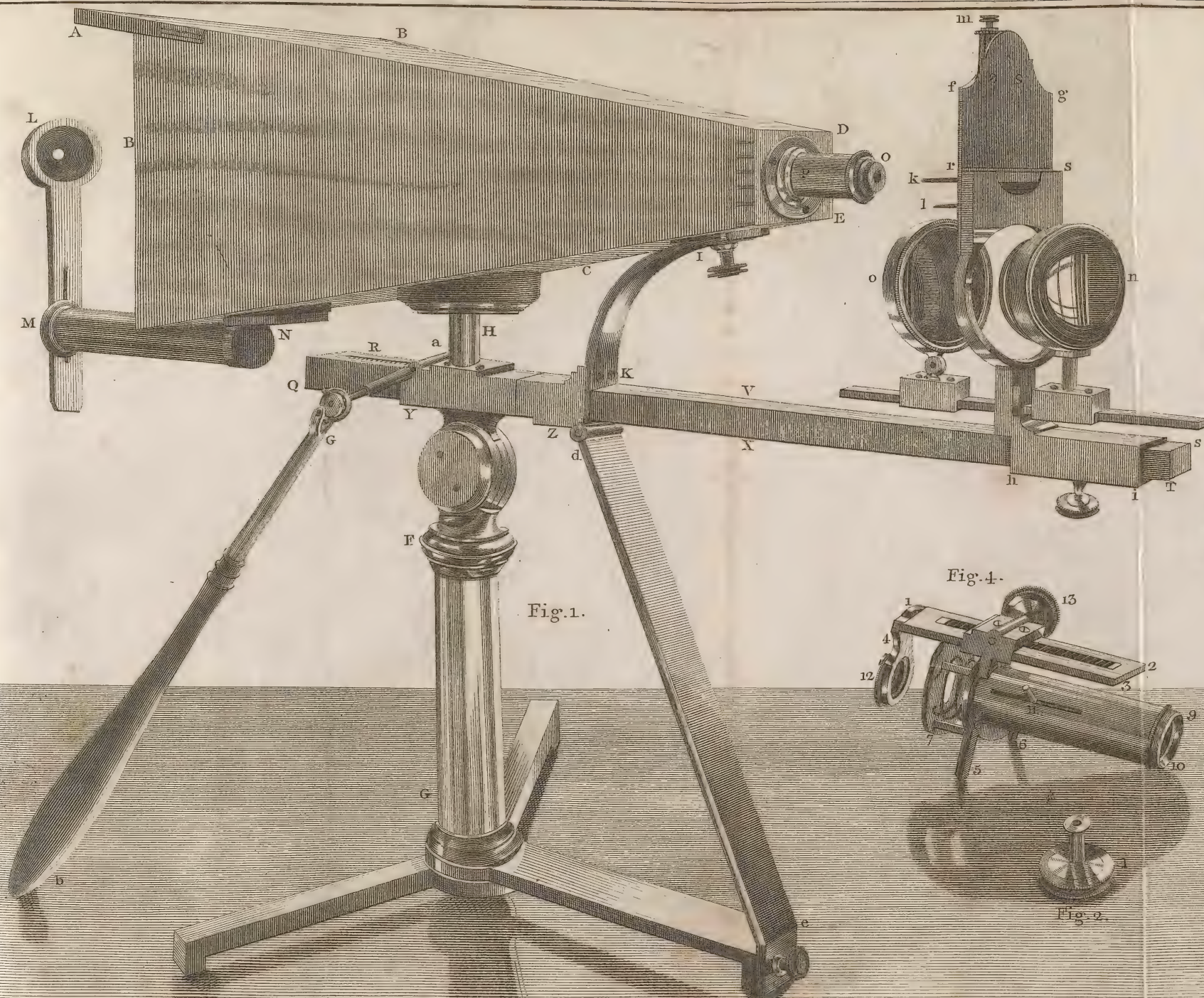


Fig. 1.



Fig. 4.

Fig. 2.

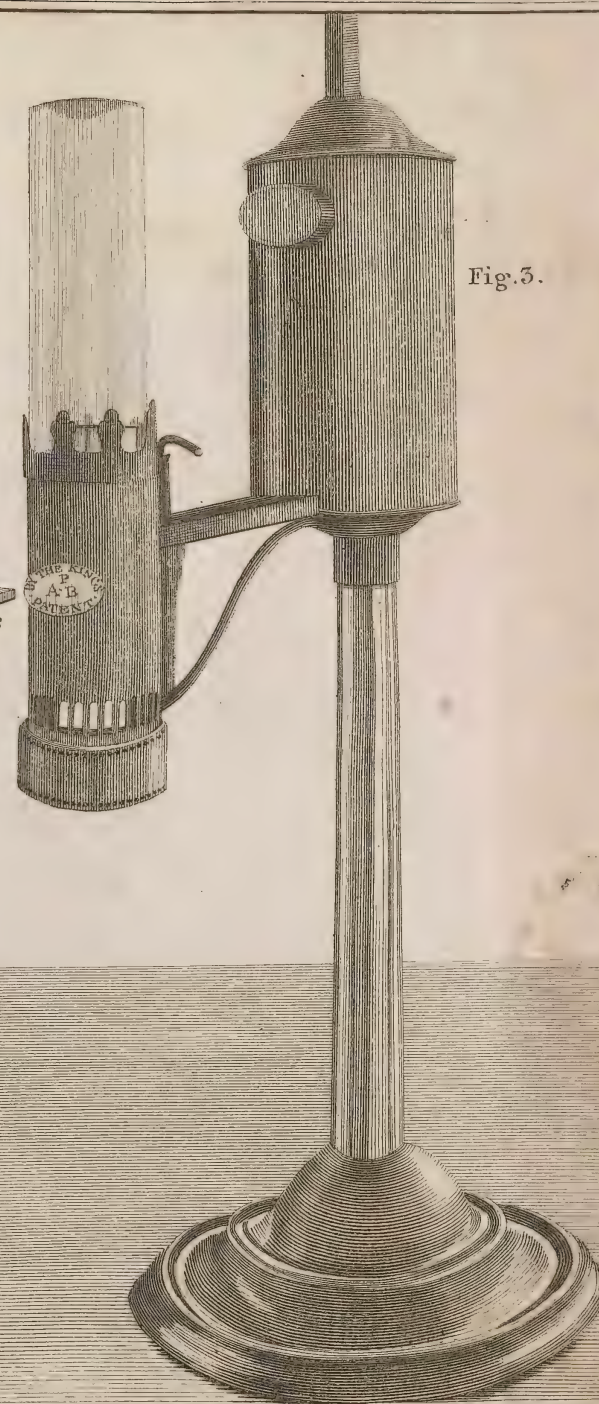


Fig. 3.



and the flame of the lamp, depends on a combination of circumstances, which a little practice will discover.

2. To regulate the guide for the eye, or to place the center of the eye-piece L, so that it may coincide with the focal point of the lenses, and the axis of vision. Lengthen and shorten the tubes M N by drawing out or pushing in the inner tube, and raising or depressing the eye-piece M L, till you find the large lens (which is placed at the end A B of the wooden body) filled by an uniform field of light, without any prismatic colours round the edge; for till this piece is properly fixed, the circle of light will be very small, and only occupy a part of the lens: the eye must be kept at the center of the eye-piece L, during the whole of the operation; which may be rendered somewhat easier to the observer, on the first use of the instrument, if he holds a piece of white paper parallel to the large lens, removing it from, or bringing it nearer to them, till he finds the place, where a lucid circle, which he will perceive on the paper, is brightest and most distinct, then to fix the center of the eye-piece to coincide with that spot; after which a very small adjustment will set it perfectly right.

3. To adjust the lenses to their focal distance. This is effected by turning the pinion a, the eye being at the same time at the eye-piece L. I often place the grey glass before the large lenses, while I am regulating the guide for the eye, and adjusting for the focal distance.

If the observer, in the process of his examination of an object, advances rapidly from a shallow to a deep magnifier, he will save himself some labour by pulling out the internal tube at O.

The upper part f g r s of the stage, is to be raised or lowered occasionally, in order to make the center of the object coincide with the center of the lens at O.

To delineate objects, the grey glass must be placed before the large lenses; the picture of the object will be formed on this glass, and the outline may be accurately taken, by going over the picture with a pencil.

The opaque part may be used in the day-time without a lamp, provided the large lenses at A B are screened from the light.

TO USE THE LUCERNAL MICROSCOPE IN THE EXAMINATION OF TRANSPARENT OBJECTS.

The microscope is to remain as before: the upper part f g s of the opaque stage must be removed, and the stage for transparent objects, represented at Fig. 4, put in its place; the end, Fig. 9 and 10, to be next the lamp.

Place the greyed glass in its groove at the end A B, and the objects in the slider-holder at the front of the stage; then transmit as strong a light as you are able on the object, which you will easily do by raising or lowering the lamp.

The object will be beautifully depicted on the grey glass: it must be regulated to the focus of the magnifier, by turning the pinion a.

The

The object may be viewed either with or without the guide for the eye; a single observer will see an object to the greatest advantage by using this guide, which is to be adjusted as we have described, page 75. If two or three wish to examine the object at the same time, the guide for the eye must be laid aside.

Take the large lens out of the groove, and receive the image on the grey glass; in this case, the guide for the eye is of no use: if the grey glass is taken away, the image of the object may be received on a paper screen.

Take out the grey glass, replace the large lenses, and use the guide for the eye; attend to the foregoing directions, and adjust the object to its proper focus. You will then see the object in a blaze of light almost too great for the eye, a circumstance that will be found very useful in the examination of particular objects; the edges of the object in this mode will be somewhat coloured, but as it is only used in this full light for occasional purposes, it has been thought better to leave this small imperfection, than by remedying it, to sacrifice greater advantages; the more so, as this fault is easily corrected, and a new and interesting view of the object is obtained, by turning the instrument out of the direct rays of light, and permitting them to pass through only in an oblique direction, by which the upper surface is in some degree illuminated, and the object is seen partly as opaque, partly as transparent. It has been already observed, that the transparent objects might be placed between the slider-holders of the stage for opaque objects, and then be examined as if opaque.

Some

Some transparent objects appear to the greatest advantage when the lens at 9 and 10 is taken away; as, by giving too great a quantity of light, it renders the edges less sharp.

The variety of views which may be taken of every object, by means of the improved lucernal microscope, will be found to be of great use to an accurate observer: it will give him an opportunity of correcting or confirming his discoveries, and investigating those parts in one mode, which are invisible in another.

TO THROW THE IMAGE OF TRANSPARENT OBJECTS ON A
SCREEN, AS IN THE SOLAR MICROSCOPE.

It has been long a microscopical desideratum, to have an instrument by which the image of transparent objects might be thrown on a screen, as in the common solar microscope; and this not only because the sun is so uncertain in this climate, and the use of the solar microscope requires confinement in the finest part of the day, when time seldom hangs heavy on the mind, but as it also affords an increase of pleasure, by displaying it's wonders to several persons at the same instant, without the least fatigue to the eye.

This purpose is now effectually answered, by affixing the transparent stage of the lucernal to a lanthorn, with one of Argand's lamps.—The lamp is placed within the lanthorn, and the end 9, 10 of the transparent stage is screwed into a female screw, which is rivetted in the sliding part of the front of the lanthorn; the magnifying lenses are to be screwed into the hole represented at 12; they are adjusted by turning the milled nut. The quantity
of

of light is to be regulated, by raising and lowering the sliding-plate, or the lamp. N.B. This part, with it's lanthorn and lamp, may be had separate from the lucernal microscope.

APPARATUS WHICH USUALLY ACCOMPANIES THE IMPROVED
LUCERNAL MICROSCOPE.

The stage for opaque objects, with it's semicircular lump of glass, and concave mirror.

The stage for transparent objects, which fits on the upper part of the foregoing stage.

The sliding tube, to which the magnifiers are to be affixed; one end of these is to be screwed on the end B of the wooden body; the magnifier in use is to be screwed to the other end of the inner tube.

Eight magnifying lenses; these are so constructed, that they may be combined together, and thus produce a very great variety of magnifying powers.

A fish-pan, such as is represented at I, Plate IX.

A steel wire L, with a pair of nippers at one end.

A small cylinder of ivory I at the other.

A slider of brass N, containing a flat glass slider, and a brass slider, into which are fitted some small concave glasses.

A pair

A pair of forceps.

Six large ivory sliders, with transparent objects, and six small ditto with ditto.

Fourteen wooden sliders, with four opaque objects in each slider, and two spare sliders.

Some capillary tubes, for viewing small animalcula.

The use and manner of using the articles of the apparatus will be more particularly explained when we describe the figures which are delineated in Plate IX.

DESCRIPTION OF CUFF'S DOUBLE-CONSTRUCTED MICROSCOPE,
REPRESENTED AT Fig. 1, Plate VII. A.

This instrument was first described by Mr. Baker, and recommended by him. It was also described by my father in the fourth edition of his *Micrographia Illustrata*, page xix.

A B C represents the body of this microscope; it contains an eye-glass at A, a broad lens at B, and a magnifier which is screwed on at C.

The body of the microscope is supported by the arm DE, from which it may be removed at pleasure.

The arm DE is fixed on the sliding bar F, and may be raised or depressed to any height within its limits.

The main pillar a b is fixed in the box b e, and by means of the brass foot d is screwed to the mahogany pedestal x Y, in which is a drawer containing all the apparatus.

O, a milled-headed screw, to tighten the bar F when the adjusting screw c g is used.

p q is the stage, or plate, which carries the objects ; it has a hole at the center n.

G a concave mirror, that may be turned in any direction, to reflect the light of the candle, or the sky, upon the object.

TO USE THIS MICROSCOPE.

Screw the magnifier you intend to use to the end c of the body, place the slider-holder P in the hole n, and the slider with the object between the plates of the slider-holder; set the upper edge of the bar DE to coincide with the divisions which correspond to the magnifier you have in use, and pinch the milled nut; now reflect a proper quantity of light upon the object, by means of the concave mirror G, and regulate the body exactly to the eye and the focus of the glasses, by the adjusting screw e g.

To view opaque objects, take away the slider-holder P, and place the object on a flat glass under the center of the body, or on one end of the jointed nippers o. Then screw the silver concave speculum to the end of the cylinder L, and slide this cylinder on the lower part of the body, so that the upper edge thereof may coincide with the line which has the same mark with the

L

magnifier

magnifier that is then used; reflect the light from the concave mirror G to the silver speculum, from which it will again be reflected on the object. The glasses are to be adjusted to their focal distance as before directed.

A LIST OF THE APPARATUS OF CUFF'S DOUBLE-CONSTRUCTED MICROSCOPE.

H a convex lens, to collect the rays of light from the sun or a candle, and condense them on the object.

L a cylindrical tube, open at each side, with a concave speculum screwed to the lower end h.

P the slider-holder; it consists of a cylindrical tube, in which an inner tube is forced upwards by a spiral spring, it is used to receive an ivory slider K, which is to be slid between the plates h and i. The cylinder P fits the hole n in the stage: the hollow part at k is designed to receive a glass tube N.

R is a brass cone, to be put under the bottom of the cylinder P, to intercept occasionally some of the rays of light.

S a box containing a concave and a flat glass, between which a small living insect may be confined; it is to be placed over the hole n.

T a flat glass, to lay any occasional object upon; there is also a concave one for fluids.

O a long steel wire, with a small pair of pliers at one end, and a point at the other, designed to stick or hold objects; it slips backwards and forwards in the short tube o; the pin p fits into the hole of the stage.

W a little round ivory box, to hold a supply of talc and rings for the sliders.

Z a hair brush, to wipe any dust off the glasses, or to take up by the other end a drop of any liquid.

V a small ivory cylinder, that fits on the pointed end of the steel wire O; it is designed for opaque objects. Light-coloured ones are to be stuck upon the dark side, and vice versa.

Y a common magnifying glass, for any occasional purpose.

M a fish-pan, whereon to fasten a small fish, to view the circulation of the blood: the tail is to be spread across the oblong hole at the small end, and tied fast, by means of a ribband fixed thereto; the knob l is to be shoved through the slit made in the stage, that the tail may be brought under the magnifier.

THE DESCRIPTION AND USE OF ADAMS'S IMPROVED DOUBLE AND SINGLE MICROSCOPE, REPRESENTED Fig. 1, Plate IV.

It is the compound microscope, which is at present in most general use. The improvements, though few in number, are essential to the use thereof. The field of view is considerably larger than in the former microscope. The stage and the mirrors

are both moveable, so that their respective distances may be easily varied. There is also a condensing glass to the stage, for increasing the density of the light, when it is reflected by the mirror from a candle or lamp. It is furnished with two mirrors, one plane, and the other concave, and may be used as a single microscope.

A B, Fig. 1, Plate IV. represents the body of the microscope, containing a double eye glass, and a body glass; it is here shewn as screwed to the arm C D, from whence it may be occasionally removed, either for the convenience of packing, or when the instrument is to be used as a single microscope.

The eye glasses and the body glasses are contained in a tube which fits into the exterior tube A B; by pulling out a little this tube, when the microscope is in use, the magnifying power of each lens is increased.

The body A B of the microscope is supported by the arm C D, this arm is fixed to the main pillar C F, which is screwed firmly to the mahogany pedestal G H; there is a drawer to this pedestal, which holds the apparatus.

N I S is the plate or stage which carries the slider-holder K L, this stage is moved up or down the pillar C F, by turning the milled nut M; this nut is fixed to a pinion, that works in a toothed rack cut on one side of the pillar. By means of this pinion, the stage may be gradually raised or depressed, and the object adjusted to the focus of the different lenses.

K L

K L is the slider-holder, which fits into a hole that is in the middle of the stage N I S; it is used to confine and guide either the motion of the sliders which contain the objects, or the glass tubes that are designed to confine small fishes, for viewing the circulation of the blood. The sliders are to be passed between the two upper plates, the tubes through the bent plates.

L is a brass tube, to the upper part of which is fixed the condensing lens before spoken of; it fits into the under part of the slider-holder ~~N I~~ and may be set at different distances from the object, according to it's distance from the mirror or the candle. This tube is seen further drawn out in Fig. 2, Plate IV.

O is the frame which holds the two reflecting mirrors, one of which is plane, the other concave. These mirrors may be moved in various directions, in order to reflect the light properly, by means of the pivots on which they move, in the semicircle Q S R, and the motion of the semicircle itself on the pin S; the concave mirror generally answers best in the day-time; the plane mirror combines better with the condensing lens, and a lamp or candle. At D there is a socket for receiving the pin of the arm Q, Plate IX. to which the concave speculum, for reflecting light on opaque objects, is fixed.

At S is a hole and slit for receiving either the nippers L, Plate IX. or the fish-pan I; when these are used, the slider-holder must be removed.

T, a hole to receive the pin of the convex lens M, Plate IX.

To

TO USE THE IMPROVED DOUBLE MICROSCOPE.

Take the microscope out of the box. Screw the body into the round end of the upper part of the arm CD.

Place the brass sliders, which contain the magnifiers, into the dove-tailed slit which is on the under side of the aforesaid arm, as seen at E, Fig. 1, Plate IV. and slide it forwards, until the magnifier you mean to use is under the center of the body: opposite to each magnifier in this slide there is a notch, and in the dove-tailed part of the arm CD there is a spring, which falls into the above-mentioned notch, and thus makes each magnifier coincide with the center of the body.

Pass the ivory slider you intend to use between the upper plates of the slider-holder KL, and then reflect as strong a light as you can on the object, by means of one of the mirrors; after this, adjust the object to the focus of the magnifier and your eye, by turning the milled screw M; the motion of this raises and depresses the stage NIS. The degree of light necessary for each object, and the accuracy required in the adjustment of the lens to their proper focal distance from the object, will be easily attained by a little practice.

When opaque objects are to be examined, remove the slider-holder, and place the object on a flat glass, or fix it to the nippers L, Plate IX. the pin of these fit into the hole on the stage; * H screw the concave speculum ~~B~~ Plate IX. into the arm Q, Plate IX.

IX. and then pass the pin of this arm through the socket D, Fig. 1, Pl. IV. the light is now to be reflected from the concave mirror to the silver speculum, and from this down on the object. No exact rule can be given for reflecting the light on the object; we must therefore refer the reader to the mother of all aptness, practice. The speculum must be moved lower or higher, to suit the focus of the different magnifiers, and the nature of the object.

The preceding directions apply equally to the using of this instrument as A SINGLE MICROSCOPE, with this difference only, that the body A B is then removed, and the eye is applied to the upper surface of the arm C D, exactly over the magnifiers.

A LIST OF THE APPARATUS OF THE IMPROVED COMPOUND MICROSCOPE.

The slider, with the magnifiers.

The body of the microscope.

The slider-holder.

The tube, with the condensing lens.

The pin and arm for the silver speculum.

The silver speculum.

A brass box for the silver speculum.

A brass

A brass cone to place under the slider-holder.

The jointed nippers.

A cylinder of ivory, to fix on the pointed end of the nippers.

Six ivory sliders, five of which are filled with objects.

A magnifier for the hand.

A fish pan.

A round brass box, with glass ends, for confining living objects.

An ivory box, to hold spare rings and talc for the sliders.

A round flat glass, fitted to the hole in the stage.

A concave ditto.

A slider of brass, containing a flat glass slider, and a brass slider, into which are fitted small concave glasses.

Some glass tubes.

A small pair of forceps.

A slip or two of flat glass.

A small brush, or hair pencil.

The

The use of each article of the apparatus, and the method of applying it to use, will be described in the latter end of this chapter.

OF THE IMPROVED COMPOUND MICROSCOPE, REPRESENTED
AT Fig. 2, Plate IV.

The advantages of this over the preceding compound microscope, consists, first, in the motion which may be given to the body, the stage, and the mirrors, by means of the joint *cd*, which has both a vertical and horizontal motion; so that the microscope may be placed either in an horizontal or inclined situation, and thus be adapted to the ease of the observer, and be used when he is sitting down. If the mirror *QOR* is taken off, the light will be conveyed in a direct line to the object, without any reflection. Secondly, that the body may be moved over any part of the stage, and thus over the object. The arm which carries the body, moves to the right or left on a central pin, and may also be moved backwards or forwards by the milled nut *b*. Thirdly, the concave and flat mirrors are much larger than those of Fig. 1. In every other respect, the microscope is similar to the foregoing, and may be managed by the description thereof; for which purpose, similar letters are affixed to the same parts.

A DESCRIPTION OF CULPEPER'S, OR THE THREE-PILLARED
MICROSCOPE, Fig. 3, Plate IV.

This instrument is recommended by it's simplicity and cheapness; it is easily managed, and gives a pleasing view of an object.

ject. It is true, it is precluded by its form from some of the advantages of the two foregoing instruments, because both the stage and the mirror are confined.

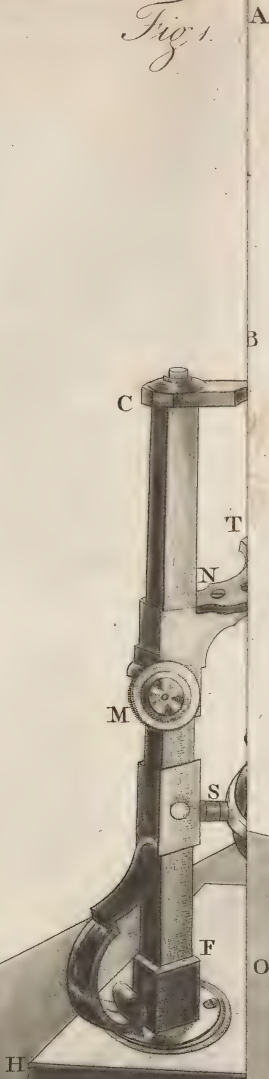
This microscope consists of a large exterior body A B C D, supported on three small scroles, which are fixed to the stage E F; the stage is supported by three larger scroles, that are screwed to the mahogany pedestal G H. There is a drawer in the pedestal which holds the apparatus. The concave mirror is fitted to a socket in the center of the pedestal. The lower part L M C D of the body forms an exterior tube, into which the upper part of the body A B L M slides, and may be moved up or down, so as to bring the magnifiers, which are screwed on at N, nearer to, or further from the object.

TO USE CULPEPER'S MICROSCOPE.

Screw one of the buttons which contains a magnifying lens, to the end N of the body; place the slider, with the objects, between the plates of the slider-holder. Then, to attain distinct vision, and a pleasing view of the object, adjust the body to the focus of the lens you are using, by moving the upper part gently up and down, and regulate the light by the concave mirror.

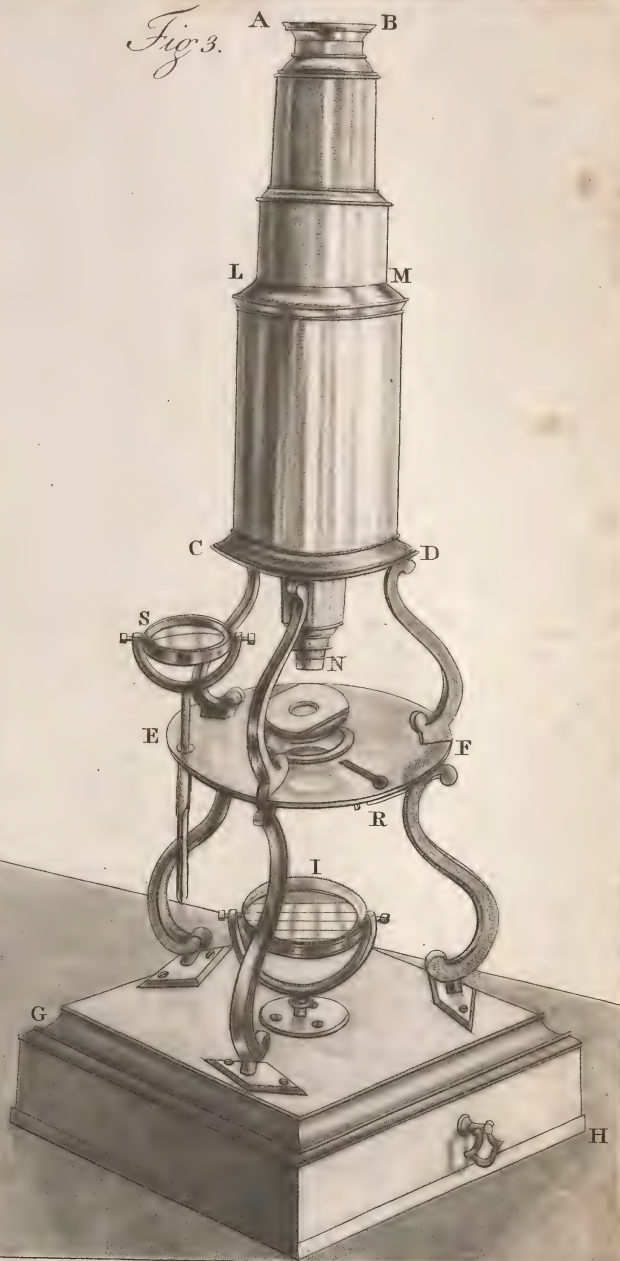
For opaque objects, two additional pieces must be used; the first is, a cylindrical tube of brass, represented at X, Plate IX. which fits on the cylindrical part at N of the body; the second piece is the concave speculum H, Plate IX. this is to be screwed to the lower end of the aforesaid tube: the upper edge of this tube should be made to coincide with the line, which has the same

Fig. 1.



Mibre delin.^t

Fig. 3.



R. Laurie sculp.^t

Fig. 1.

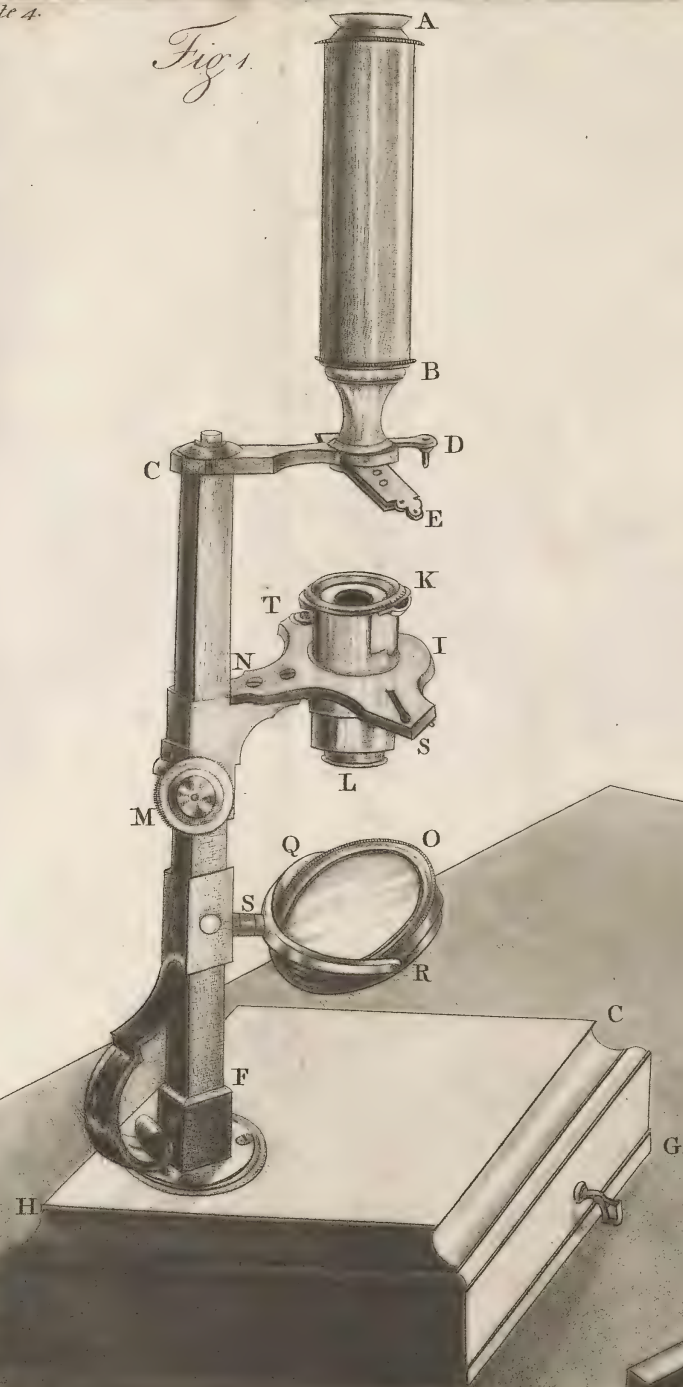


Fig. 2.

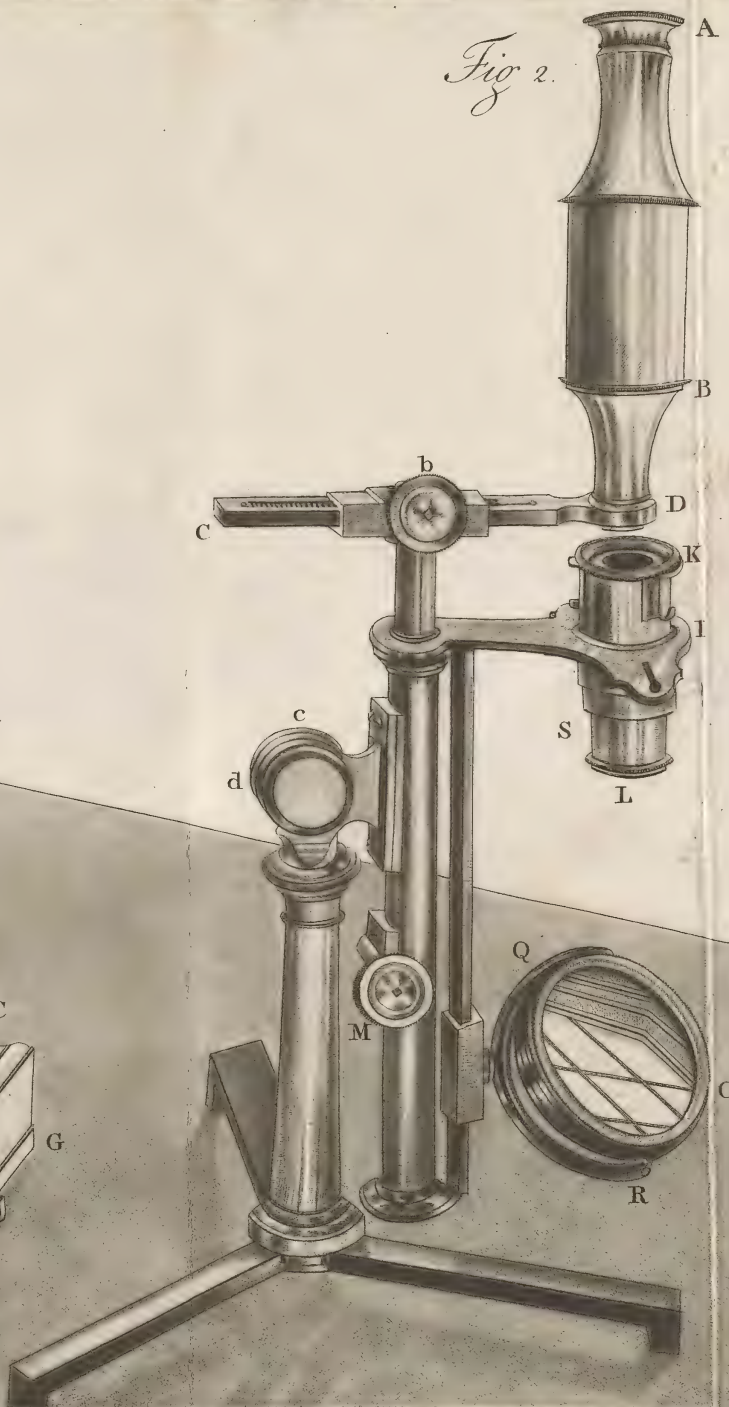
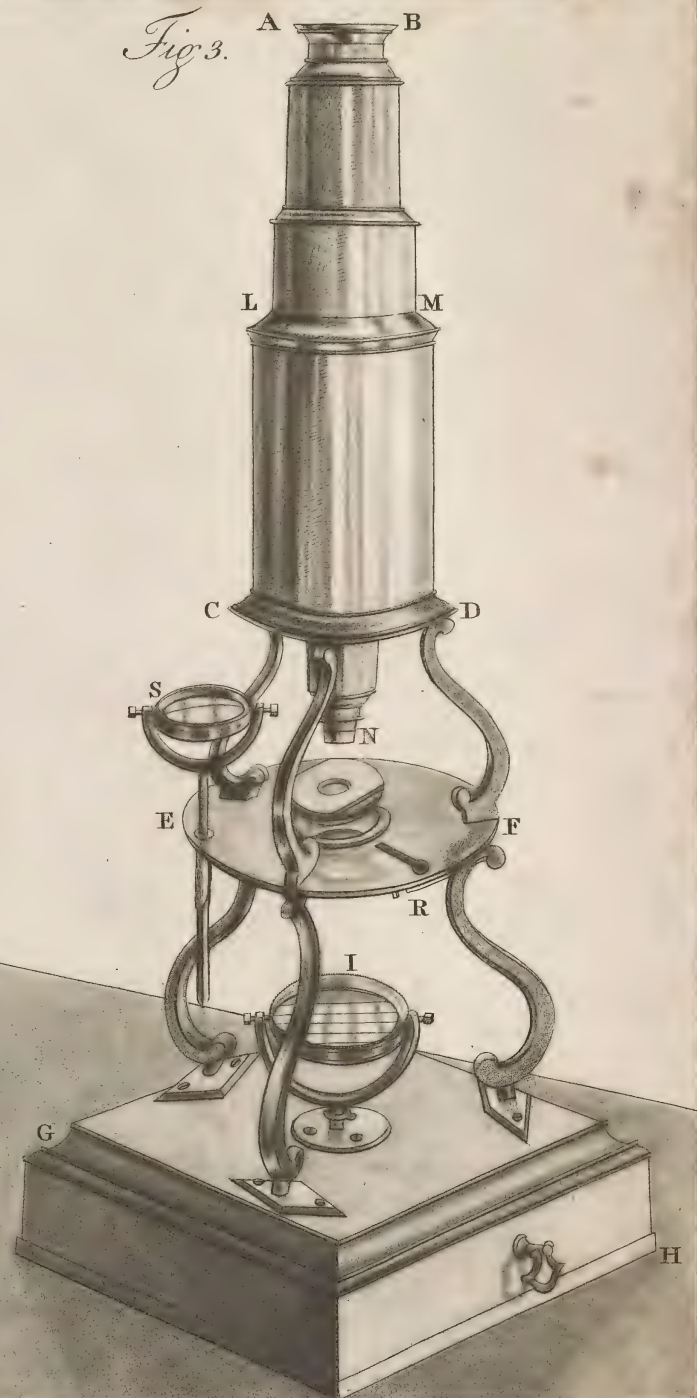


Fig. 3.



Milne delin.

R. Laurie sculp.



number affixed to it, as to the magnifier you are using; ex. gr. if you are making use of the magnifier marked 5, slide the tube to the circular line on the tube N, that is marked also with No. 5.

The slider-holder should be removed when you are going to view opake objects, and a plane glass should be placed on the stage in it's stead to receive the object; or it may be placed in the nippers L, Plate IX. the pin of which fits into the hole in the stage.

A LIST OF THE APPARATUS TO CULPEPER'S MICROSCOPE.

Five magnifiers, each fitted in a brass button; one of these is seen at B, Plate IX.

Six ivory sliders, five of them with objects.

A brass tube X, Plate IX. to hold the concave speculum.

The concave speculum in a brass box.

A fish-pan.

A set of glass tubes.

A flat glass fitted to the stage.

A concave glass fitted to the stage.

M 2

A pair

A pair of forceps.

A steel wire, with a pair of nippers at one end, and a point at the other.

A small ivory cylinder, to fit on the pointed end of the afore-said nippers.

A convex lens, moveable in a brass semicircle; this is affixed to a long brass pin, which fits into a hole on the stage.

If the reader wants a more particular description of any of the articles of this apparatus, he will find it at the latter end of this chapter.

A DESCRIPTION OF THE IMPROVED SOLAR MICROSCOPE,
WHICH IS CONSTRUCTED TO EXHIBIT TRANSPARENT AND
OPAQUE OBJECTS, Fig. 1, Plate V.

The solar microscope is generally supposed to afford the most entertainment, on account of the wonderful extent of its magnifying power, and the ease with which several persons may view each single object at the same time. The use of it was, however, confined for many years only to transparent objects. About the year 1774, Mr. B. Martin so far improved this instrument, as to render it applicable to opaque, as well as to transparent objects, exhibiting the magnified image of either kind on a large screen. Speaking of it himself, he says, "With this instrument all opaque objects, whether of the animal, vegetable, or mineral kingdom, may be exhibited in great perfection, in all their native beauty; the

the lights and shades, the prominencies and cavities, and all the varieties of different hues, tints, and colours, heightened by the reflection of the solar rays condensed upon them." Transparent objects are also shewn with greater perfection than in the common solar microscope.

Fig. 1, Plate V. represents the solar opaque microscope, mounted for exhibiting opaque objects.

Fig. 2, is the single tooth and pinion microscope, which is used for shewing transparent objects; the cylindrical tube Y thereof being made to fit into the tube F E, Fig. 1.

Fig. 3, the slider which contains the magnifiers; it fits into a dove-tail which is at the upper part of the microscope, Fig. 2.

A B C D E F, Fig. 1, represents the body of the solar microscope; one part thereof, A B C D, is conical; the other, C D E F, is cylindrical. The cylindrical part receives the tube G of the opaque box, or the tube Y of the single microscope, Fig. 2.

At the large end A B of the conical part, there is a lens to receive the rays from the mirror, and refract them towards the box. H I K L.

N O P is a brass frame, which is fixed to the moveable circular plate a b c; in this frame there is a plane mirror, to reflect the solar rays on the afore-mentioned lens.

This mirror may be moved into the most convenient position for reflecting the light, by means of the nuts Q and R.
By

By the nut Q it may be moved from east to west; it may be elevated or depressed by the nut R.

d e, two screws to fasten the microscope to a window-shutter.

The box for opaque objects is represented at H I K L; it contains a plane mirror M, for reflecting the light that it receives from the large lens to the object, and thereby illuminating it; S is a screw to adjust this mirror, or place it at a proper angle for reflecting the light.

V X two tubes of brass, one sliding within the other, the exterior one in the box H I K L; these carry the magnifying lenses: the interior tube is sometimes taken out, and the exterior one is then used by itself. Part of this tube may be seen in the plate within the box H I K L.

At H there is a brass plate, the back part of which is fixed to the hollow tube h, in which there is a spiral wire, which keeps the plate always bearing against the side H of the brass box H I K L. The sliders, with the opaque objects, pass between this plate and the side of the box; to put them there, the plate is to be drawn back by means of the nut g.

i k, a door to one side of the opaque box.

The foregoing pieces constitute the several parts necessary for viewing opaque objects. I shall now proceed to describe the single microscope, which is used for transparent objects: but in order to examine these, the box H I K L must be first removed, and in
it's

it's place we must insert the tube Y of the single microscope that we are now going to describe.

Fig. 2, Plate V. represents a large tooth and pinion microscope; at m, within the body of this microscope, are two thin plates, that are to be separated, in order to let the ivory sliders pass between them; they are pressed together by a spiral spring, which bears up the under plate, and forces it against the upper one.

The slider, Fig. 3, that contains the magnifiers, fits into the hole n; any of the magnifiers may be placed before the object, by moving the aforesaid slider: when the magnifier is at the center of the hole P, a small spring falls into one of the notches which is on the side of the slider, Fig. 3.

Under the plate m are placed two lenses, for enlarging the field of view on the screen: the smaller of the two is fixed on a piece of brass, and is nearest the plate m; this is to be taken out, when the magnifiers, No. 4, 5, or 6, are used, or when the megalascope lens, Fig. 4, is used; but is to be replaced for No. 1, 2, 3.

This microscope is adjusted to the focus, by turning the milled nut O.

TO USE THE SOLAR MICROSCOPE.

Make a round hole in the window-shutter, a little larger than the circle a b c; pass the mirror C N P through this hole, and apply the square plate to the shutter; then mark with a pencil
the

the places which correspond to the two holes through which the screw is to pass; take away the microscope, and bore two holes at the marked places, sufficiently large to let the milled screws pass through them.

These screws are to pass from the outside of the shutter, to go through it, and being then screwed into their respective holes in the square plate, they will, when screwed home, hold it fast against the inside of the shutter, and thus support the microscope.

Screw the conical tube *ABCD* to the circle *abc*, and then slide the tube *G* of the opaque box into the cylindrical part *CD EF* of the body, if opaque objects are to be examined; but if they be transparent objects you mean to shew, then place the tube *Y* within the tube *CDEF*.

The room is to be darkened as much as possible, that no light may enter but what passes through the body of the microscope; for, on this circumstance, together with the brightness of the sunshine, the perfection and distinctness of the image in a great measure depend.

I shall first consider the microscope as going TO BE USED FOR OPAQUE OBJECTS. 1. Adjust the mirror *NOP*, so as to receive the solar rays, by means of the two finger screws or nuts, *Q, R*; the first, *Q*, turns the mirror to the right or left; the second, *R*, raises or depresses it: this you are to do till you have reflected the sun's light through the lens at *A B*, strongly upon a screen of white paper, placed at some distance from the window, and formed thereon a round spot of light. An unexperienced observer will find it more
conve-

convenient to obtain the light, by forming this spot before he puts on either the opake box, or the tooth and pinion microscope.

* Now put in the opake box, and place the object between the plates at H; open the door i k, and adjust the mirror M, till you have illuminated the object strongly. If you cannot effect this by the screw S, you must move the screws Q, R, in order to get the light reflected strongly from the mirror NOP, on the mirror M, without which the latter cannot illuminate the object.

The object being strongly illuminated, shut the door i k, and a distinct view of the object will soon be obtained on your screen, by adjusting the tubes V X, which is effected by moving them backwards or forwards.

A round spot of light cannot always be procured in northern latitudes, the altitude of the sun being often too low; neither can it be obtained when the sun is directly perpendicular to the front of the room.

As the sun is continually changing it's place, it will be necessary, in order to keep his rays full upon the object, to keep them continually directed through the axis of the instrument, by the two screws Q and R.

To view transparent objects, remove the opake box, and insert the tube Y of Fig. 2, Plate V. in it's place; put the slider, Fig. 3, Plate V. into it's place at n, and the slider, with the objects between the plates, at m; then adjust the mirror NOP, as before directed, by the screws Q, R, so that the light may pass through

N

the

the object; regulate the focus of the magnifier by the screw O. The most pleasing magnifiers in use are the fourth and fifth.

The size of the object may be increased or diminished, by altering the distance of the screen from the microscope: five or six feet is a convenient distance.

TO EXAMINE TRANSPARENT OBJECTS OF A LARGER SIZE, or to render the instrument what is usually called a megalascope, take out the slider, Fig. 3, from it's place at n, and screw the button, Fig. 4, into the hole at P, Fig. 2, and remove the glass which is under the plate at m, and regulate the light and focus agreeable to the foregoing directions.

N. B. At the end of the tube G there is a lens for increasing the density of the rays, for the purpose of burning or melting any combustible or fusible substance; this lens must be removed in most cases, lest the objects should be burnt. The intensity of the light is also varied by moving this tube backwards or forwards.

APPARATUS OF THE OPAKE SOLAR MICROSCOPE.

The large square plate and mirror.

The body of the microscope.

The opake box and it's tube.

The tooth and pinion microscope.

The

Fig. 2

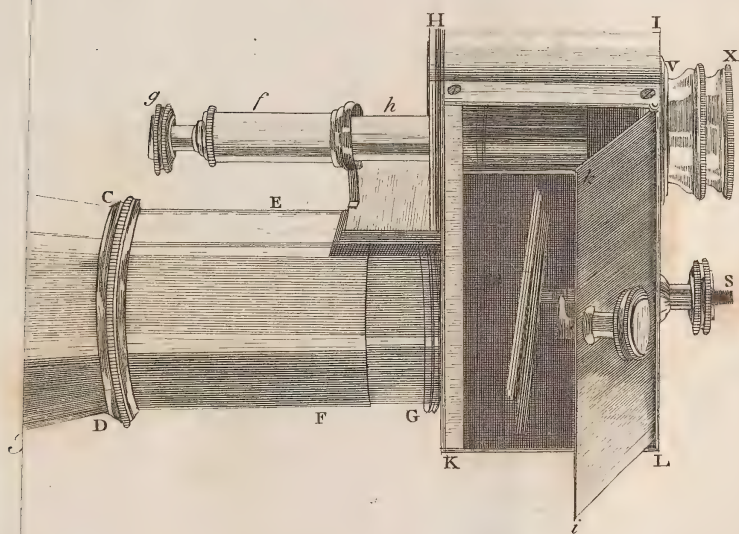
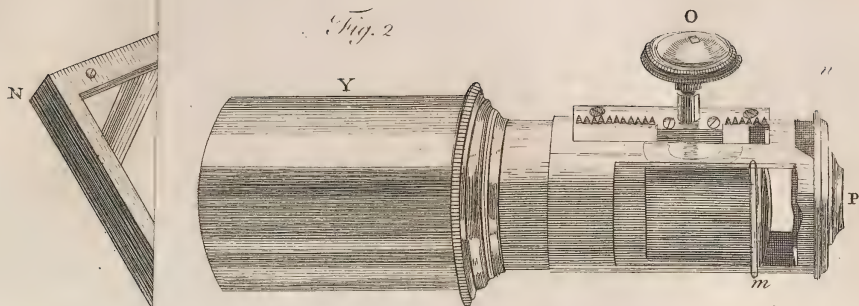
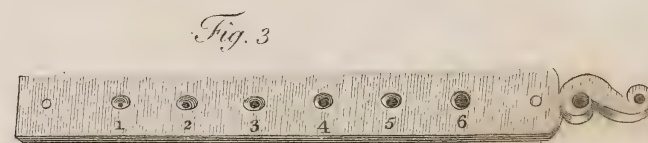
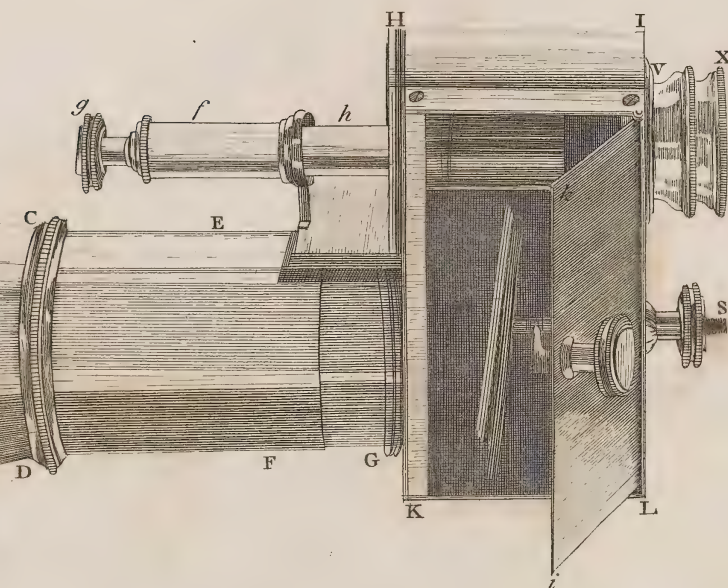
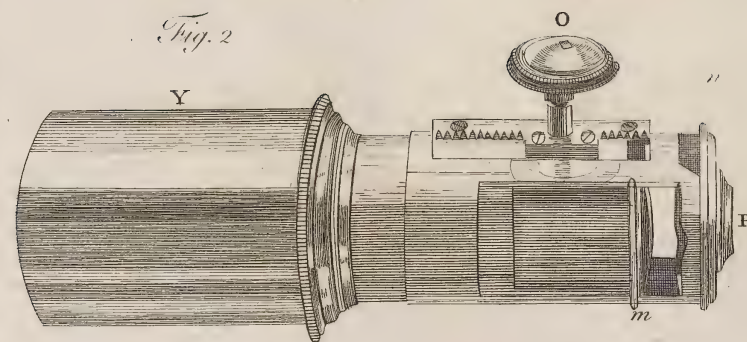
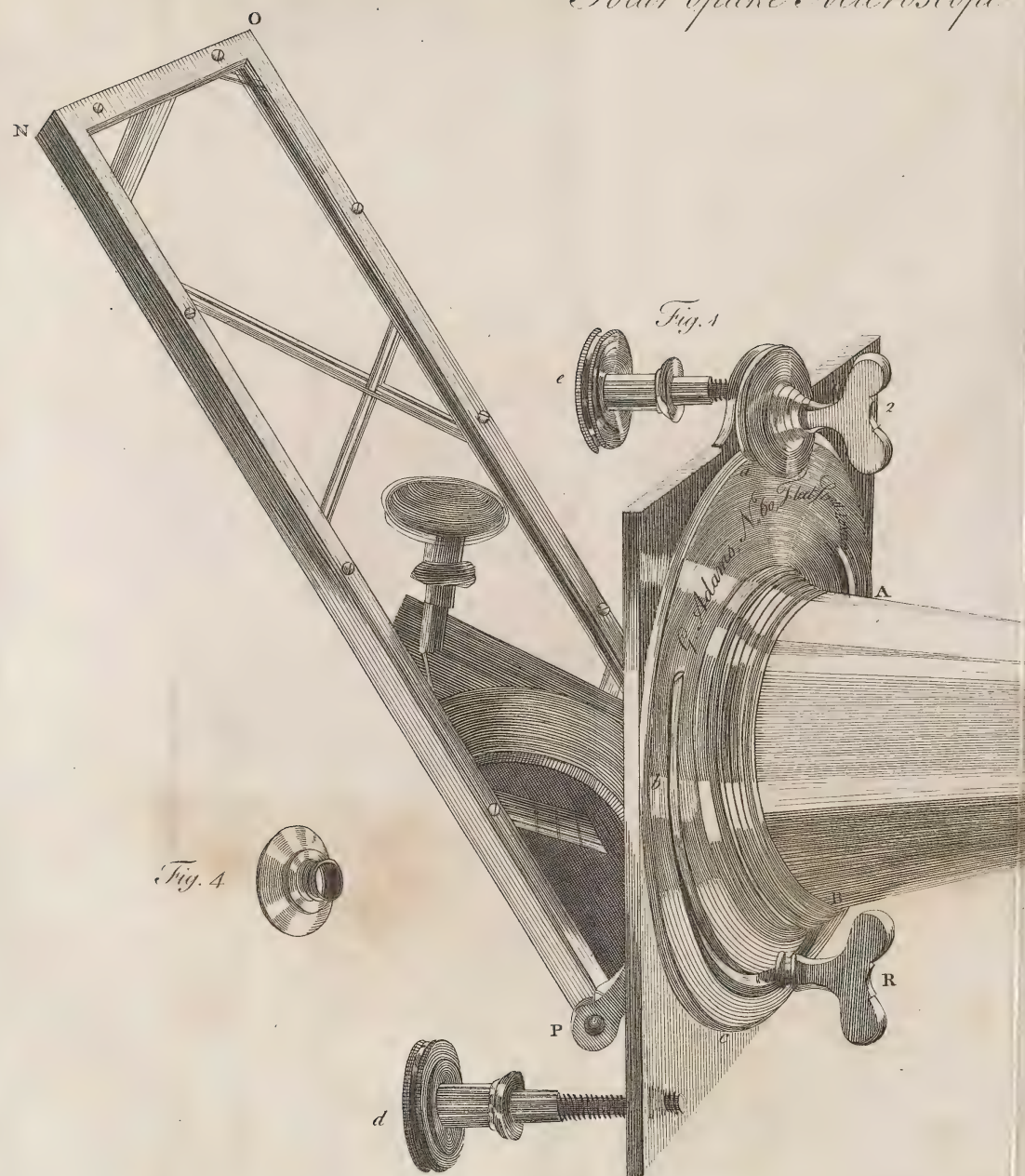


Fig. 3



Street May 20th 1787.

Solar opake. Microscopes



The slider with the magnifiers.

The megalascope magnifier.

The two screws Q and R.

Some ivory sliders.

Some sliders with opaque objects.

A brass frame, with a bottom of soft deal to stick any object on.

A brass cylinder K, Plate IX. for confining opaque objects.

DESCRIPTION OF THE COMMON SOLAR MICROSCOPE,
Fig. 4, Plate VI.

The foregoing description will, in a great part, answer for this microscope; and I once intended to have made only some general references to the former, in order to avoid that prolixity which must ever attend the detail of description: but when I considered, that one of these instruments might be purchased by those who would probably never see the other; and that a small difference in construction would embarrass the young practitioner, it appeared to me more eligible to give a description of the common solar at full length, than to curtail it through an affectation of brevity.

This instrument is represented in Plate VI. at the Figures 4, 5, 6, 7, 8.

N 2

A B

A B C D, Fig. 4, represents the body of the microscope, consisting of two brass tubes. E F is the top of the inner moveable tube; the end e f of the single tooth and pinion microscope, Fig. 5, screws into the top of this inner tube; at the end A B of the external tube there is a lens, to receive the light of the sun from the mirror K L, and to collect and condense it on the object; the end A B screws into the circular plate G H I.

K L, a long frame fixed to the moveable circular plate; in this frame there is a plane mirror to reflect the rays of the sun on the lens at A B.

An endless worm or screw, which is cut on the lower part of the nut M, works in a small wheel which is fixed to the frame K L, so that by turning the nut, the frame K L is moved up or down: the nut N moves the mirror to the right or left.

O, P, two screws to fasten the square plate to the window-shutter.

Fig. 5, the single microscope; e f the end which screws on to the upper part E of the internal tube of the body; q the dovetailed slit for receiving the slider, Fig. 8,

g, the hole in which the megalascope magnifier, Fig. 6, is to be screwed, when the slider, Fig. 8, is removed.

At h are the moveable plates, between which the sliders are placed; under the lowermost of these the lens represented at Fig.

7 is to be placed, when the magnifiers, No. 1, 2, 3, and 4, are to be used.

e k is a small piece of rack work, which is moved backwards and forwards by the pinion that is fixed to the lower end of the milled nut b: by the gradual motion of this rack, the objects are adjusted to the foci of the different lenses.

Fig. 8 is a brass slider, with four or six lenses or magnifying glasses; it is to be inserted into the hole at q; either of the magnifiers may be placed before the object, by sliding it one way or the other: you may perceive when the glass is in the center of the eye-hole by a small spring falling into a notch which is made on the side of the slider opposite to each lens.

TO USE THE SOLAR MICROSCOPE.

Fasten the square plate against the inside of a window-shutter, by the two screws O, P, which are to go from the outside of the window-shutter through it, and then be screwed into their respective holes in the square plates G H I. The mirror is to be on the outside of the shutter, passing through a hole made for that purpose.

Darken the room; then place a screen at a convenient distance from the window, the farther it is from it the larger is the image: now move the mirror K L by the two nuts M, N, till the sun's rays come through the instrument in an horizontal direction to the screen, forming a round spot thereon; screw the microscope, Fig. 5, into it's place E F; put the slider, with the lens, Fig. 8,
in.

in it's proper situation, and the object slider between the plates at h; adjust the object to the focus of the magnifying lens by the screw b, till the object appears distinct and clear on the screen. By moving the internal tube of the body, the object may be placed at different distances from the lens which is fixed at A B, so as to be sufficiently illuminated, and yet not scorched by the solar rays.

APPARATUS BELONGING TO THE COMMON SOLAR MICROSCOPE.

Square plate and mirror.

The body, consisting of two tubes, one within the other.

The single microscope.

The megalascope lens, Fig. 6.

The slider, Fig. 8, with six lenses.

The two screws O, P.

Six ivory sliders and a talc box.

Some glass tubes.

A slider, or brass case, containing a plane piece of glass, and a brass slider with holes, into which are cemented small concave glasses, designed for confining small insects between the plane and

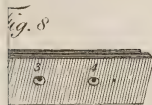
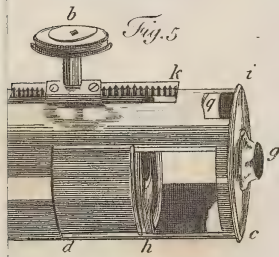
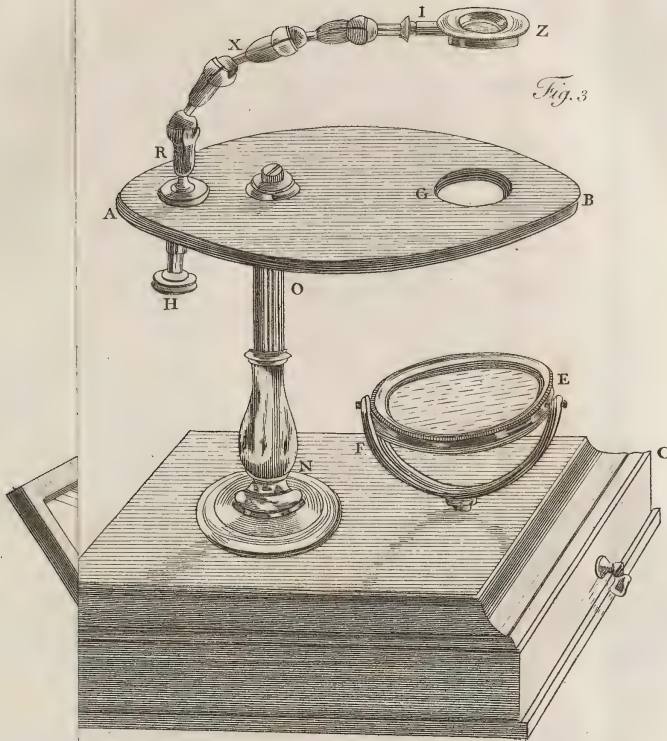


Fig. 1

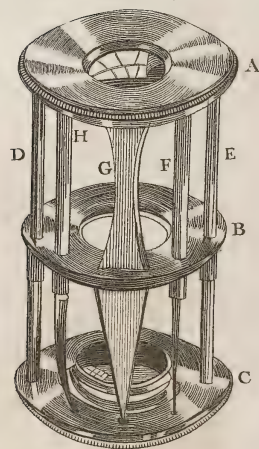


Fig. 2

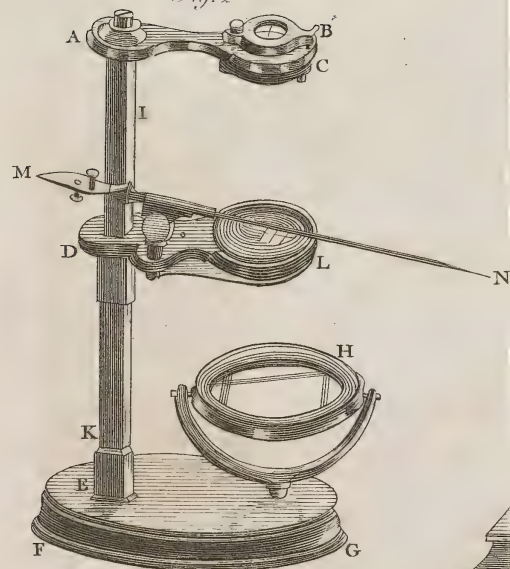


Fig. 3

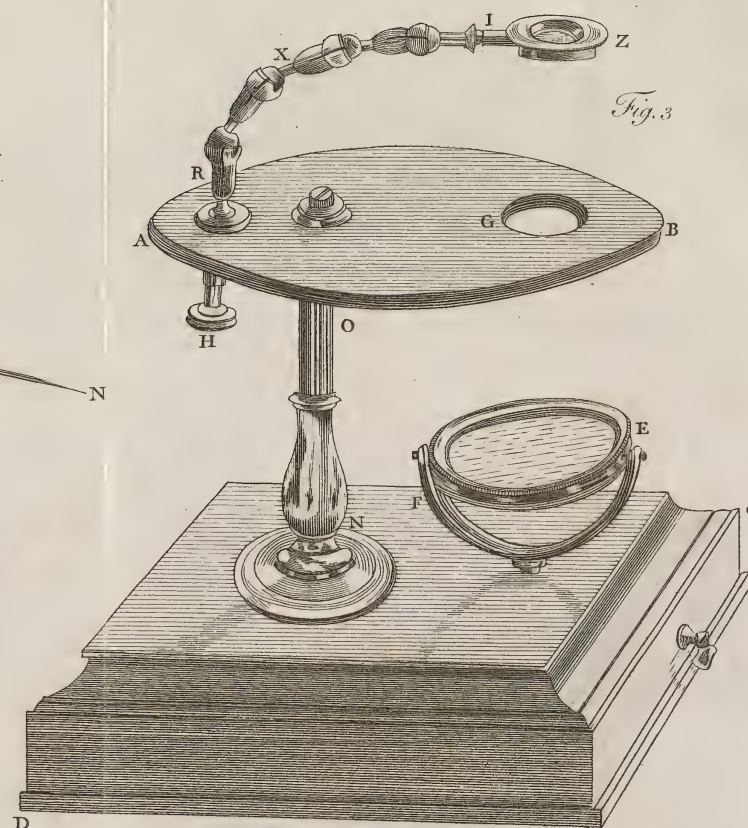


Fig. 4

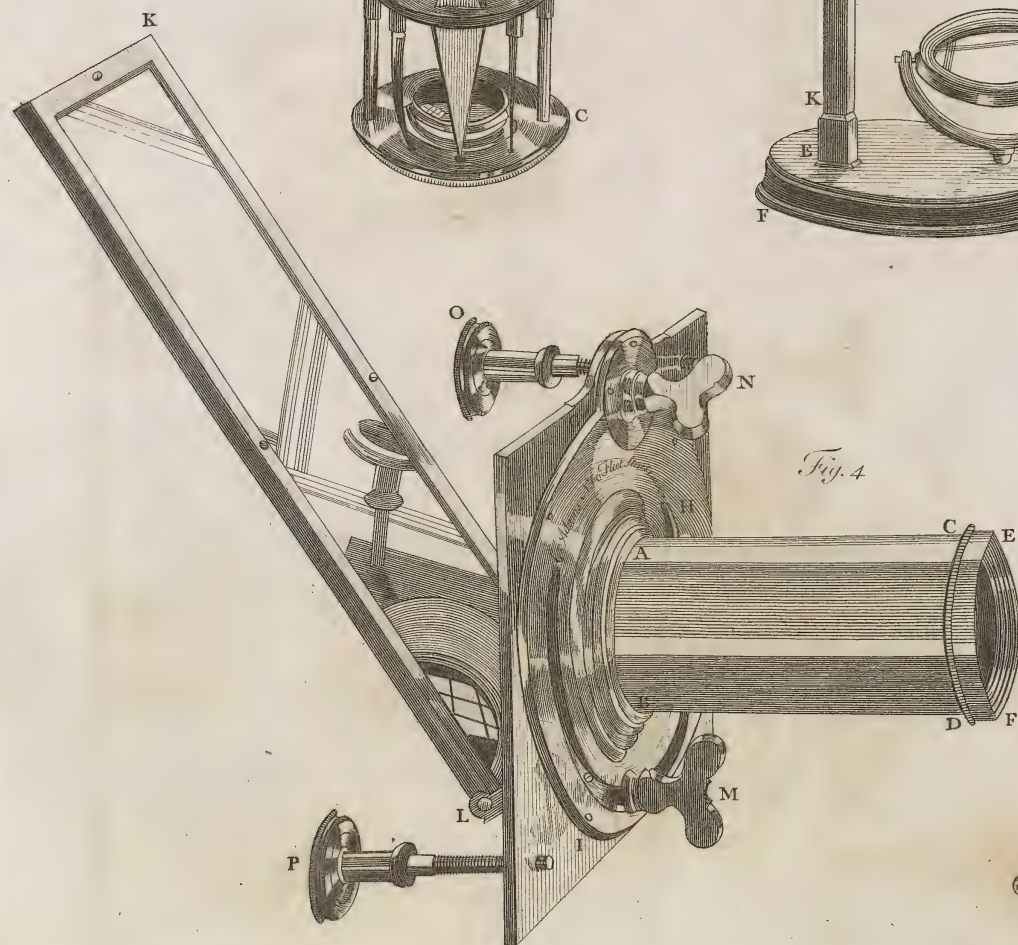


Fig. 5

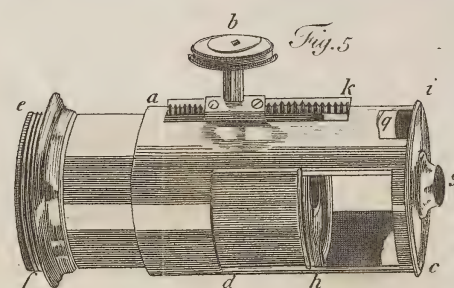


Fig. 6



Fig. 7

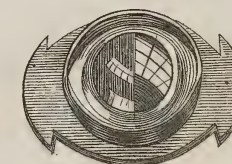


Fig. 8



concave glafs, which are thus preserved from being cruſhed, and prevented from wandering out of the field of view.

THE SCREW BARREL, OR WILSON'S SINGLE POCKET
MICROSCOPE, Fig. 1 and 2, Plate H. B.

This microscope of Mr. Wilſon's is an invention of many years ſtanding, and was in ſome meaſure laid aſide, till Dr. Lieberkuhn introduced the ſolar apparatus, to which he applied it, there being no other inſtrument at that time which would anſwer his purpoſe ſo well; ſince which time it has been revived, and much eſteemed, though very troubleſome in many caſes.

The body of the microscope is repreſented by A B, Fig. 1, and is made either of ſilver, braſs, or ivory.

C C is a long fine-threaded male ſcrew that turns into the body of the microſcopè.

D, a convex glaſs at the end of the ſaid ſcrew, on which may be placed, as occaſion requires, one of the two concave pieces of thin braſs, with holes of different diameters in the center of them, to cover the ſaid glaſs, and thereby diminifh the aperture when the greateſt magnifiers are uſed.

E, three thin plates of braſs within the body of the microscope, one whereof is bent ſemicircularly in the middle, ſo as to form an arched cavity for the reception of a tube of glaſs.

F, a piece of wood or brass, arched in the manner of the said plate, and fastened thereto.

G, the other end of the microscope, where a hollow female screw is adapted to receive the different magnifiers.

H, a spiral spring of steel between the said end G and the plates of brass E, intended to keep the plates in a due position, and counteract against the long screw C.

I, a small turned handle, for the better holding the instrument, which screws on and off at pleasure.

To this microscope belong seven different magnifying glasses, six of which are set either in silver, brass, or ivory, as in the figure K, and are marked 1, 2, 3, 4, 5, 6: observe, the lowest numbers are the greatest magnifiers. L is the seventh magnifier, set in the manner of a little barrel, to be held in the hand for viewing any larger object.

M is a flat slip of ivory, called a slider, with four round holes through it, wherein to place objects between two muscovy talcs.

Six such ivory sliders, and one of brass, are usually fold with this microscope, some with objects placed in them, and others empty, for viewing any thing that may offer; but whoever pleases to make a large collection of objects, may have as many as he desires. There is also a brass slider, not expressed in the figure, to confine any small object, that it may be viewed without crushing or destroying it.

N is a pair of forceps, or pliers, for the taking up of insects or other objects, and adjusting them in the glasses.

O, a little hair brush or pencil, wherewith to take up and examine a small drop of liquid.

P is a tube of glass to confine living objects, such as frogs, fishes, &c. in order to discover the circulation of the blood.

When you would view an object, thrust the ivory slider, in which the said object is placed, between the two flat brass plates, observing always to put that side of the slider where the brass rings are farthest from the eye; then screw in the magnifying glass you intend to use at the end of the instrument G, and looking through it against the light, turn the long screw CC till your object is brought to the true focal distance, which you will know by it's appearing perfectly clear and distinct.

The way of examining any object accurately, is to look at it, first, through a magnifier that will shew the whole at once, and afterwards to inspect the several parts more particularly with one of the greatest magnifiers; for thus you will gain a true idea of the whole, and all it's parts: and though the greatest magnifiers can shew but a minute portion of any object at once, such as the claw of a flea, the horn of a louse, or the like, yet by gently moving the slider that contains your object, the eye will gradually see the whole; and if any part should be out of the focal distance, the screw CC will easily bring it to the true focus.

O

As

As objects must be brought very near the glasses when the greatest magnifiers are used, be particularly careful not to scratch them, by rubbing the slider against them as you move it in or out. A few turns of the screw C C will easily prevent this mischief, by giving it room enough.

DESCRIPTION OF A SCROLE FOR FIXING WILSON'S POCKET MICROSCOPE, AND REFLECTING LIGHT TO IT BY A MIRROR.

A B C, Fig. 2, is a brass scrole, which, for the better convenience of carriage, is so ordered as to take into three parts, and put into the drawer upon which it stands, with its reflecting mirror and Wilson's pocket microscope.

The top part of the scrole is taken off at B, by unscrewing half a turn of the screw; then lift it up, and it comes out of the socket. The lower part unscrews at C, and the base unscrews at E.

The mirror lifts out at F, which, with the scrole, lie in one partition of the box.

To apply this scrole to use, fix the body of the microscope to the top thereof by the screw A, as in Fig. 2, by screwing it in the same hole as the ivory handle.

The brass or ivory slider being fixed as before described, and the microscope placed in a perpendicular position, move the reflecting glass D in such a manner as to cast the light of the sky,

the

the sun, or a candle, directly upwards through the microscope; by which means it is made to answer most of the ends of a double reflecting microscope.

It is also rendered more useful for viewing opaque objects by screwing the arm Q R, Fig. 1, into the body of the microscope at G; then screwing into the round hole R that magnifier which you think will best suit your object, and putting the concave speculum S, on to the outside of the ring R, you will find in the body of the microscope, between the wood or brass F, and the end of the male screw C C, a small hole u, through which slides the long wire T, which has a point at one end and forceps at the other, that may be used occasionally, as your object requires: when you have fixed this, and your object on it, turn the arm R, which is performed by two motions, till the magnifier is brought over the object; it may be then adjusted to the true focus, by turning the male screw C C in the same manner as before described. It must also be turned exactly over the speculum, by twisting the upper part of the scrole to one side, till your object and the two speculums are in one line, as will be found by trial; and then fix it by the screw B, at which time the upper surface of the object will be so exceedingly enlightened by the light reflected upward from the mirror to the concave speculum, as to be seen as clear and distinct as any transparent one.

DESCRIPTION OF A SMALL MICROSCOPE FOR OPAQUE OBJECTS,
Fig. 3 and 4, Plate II. B.

A, Fig. 4, is a fixed arm, through which passes a screw B, the other end whereof is fastened to the moveable arm C.

O 2

D is

D is a nut fitted to the said screw, which, when turned, will either separate or bring together the two arms A C.

E is a steel spring, that separates the two sides when the nut is unscrewed.

F, a piece of brass turning round in a socket, whence proceeds a springing tube, moving on a rivet, through which runs a steel wire, one end of which finishes in a point G, and the other end hath a pair of pliers H foldèd to it; these are either to thrust into, or to take up and hold any object, and may be turned round as required.

I, a ring of brass, with a female screw fixed on an upright piece of the same metal, which turns on a rivet, that it may be set at a due distance when the least magnifiers are used, and serves the screws of all the magnifiers.

K, a concave speculum of silver, polished as bright as possible, in the center of which a double convex lens is placed, with a proper aperture to look through it. On the back of this speculum a male screw L is made to fit the brass ring I, which may be screwed into the said ring at pleasure.

Four of these concave specula, of different depths, are fitted to four glasses of different magnifying powers, to be used as the objects to be examined may require. The greatest magnifiers have the least apertures.

M, a

M, a round object plate, one side white, and the other black, intended to render objects the more visible, by placing them, if black, upon the white, and if white, on the black side.

A steel spring N turns down on each side, to make any object fast: from the object plate there is a hollow pipe, to screw it on the needle's point G.

O, a small box of brass, with a glass on each side, contrived to confine any living object in order to examine it; this also has a pipe to screw upon the end of the needle at G.

P, a turned handle of ivory, to screw into the instrument when it is made use of.

Q, a pair of pliers to take up any object, or manage it with conveniency.

R, a soft hair brush, to clean the glasses or specula.

When you would view any object, screw the speculum, with the magnifier you intend to use, into the brass ring I; place your object either on the needle G, in the pliers H, on the object plate M, or in the brass hollow box O, as may be most convenient, according to the nature and condition of it; then holding up your instrument by the handle P, look against the light through the magnifying lens, and by means of the nut D, together with the motion of the needle, by managing it's lower end, the object may be turned about, raised or depressed, brought nearer the glass, or put farther from it, till you hit the true focal distance,

distance, and the light be seen reflected from the speculum strongly upon the object, by which means it will appear very distinct and clear.

OF ELLIS'S SINGLE OR AQUATIC MICROSCOPE, Plate VII. B.

This instrument takes its name from Mr. John Ellis, author of "An Essay towards a Natural History of Corallines," and of the "Natural History of many curious and uncommon Zoöphytes." This was the instrument that he made use of, and by which he was enabled to explain many singularities in the œconomy and construction of these wonderful productions of nature. To the practical botanist this instrument is recommended, by the respectable authority of Mr. Curtis, author of the *Flora Londinensis*, a work which does credit to the author and the nation. This microscope is simple in its construction, easy in its use, and very portable; these advantages, as well as some others which it also has over every other portable microscope, have accelerated the sale thereof, and caused it to be very much adopted.

DESCRIPTION OF THE VARIOUS PARTS OF THE MICROSCOPE.

K, the box which contains the whole apparatus; it is generally made of fish-skin; on the top of the box there is a female screw, for receiving the screw which is at the bottom of the pillar A, a pillar of brass which is screwed on the top of the box K.

D, a brass pin which fits into the pillar; on the top of this pin is a hollow socket to receive the arm which carries the magnifiers;
the

the pin is to be moved up and down, in order to adjust the lenses to their focal or proper distance from the object.

N. B. In the representation of this microscope, Plate VII. B. Fig. 1, the pin D is delineated as passing through a socket at one side of the pillar A; whereas it is usual at present to make it pass down a hole bored through the middle of the pillar.

E, the bar which carries the magnifying lens; it fits into the socket X which is at the top of the pillar D. This arm may be moved backwards and forwards in the socket X, and sideways by the pin D, so that the magnifier, which is screwed into the ring at the end E of this bar, may be easily made to traverse over any part of the object that lays on the stage or plate B.

E F is a polished silver speculum, with a magnifying lens, placed at the center thereof, which is perforated for this purpose. The silver speculum screws into the arm E as at F.

G, another speculum, with it's lens, which is of a different magnifying power from the former.

H, the semicircle which supports the mirror I; the pin R, affixed to the semicircle H, passes through the hole which is towards the bottom of the pillar A.

B, the stage, or the plane, on which the objects are to be placed; it fits into the small dove-tailed arm which is at the upper end of the pillar D A.

C, a plane glass, with a small piece of black silk stuck on it; this glass is to lay in a groove made in the stage B.

M, a hollow glass, to be laid occasionally on the stage instead of the plane glass C.

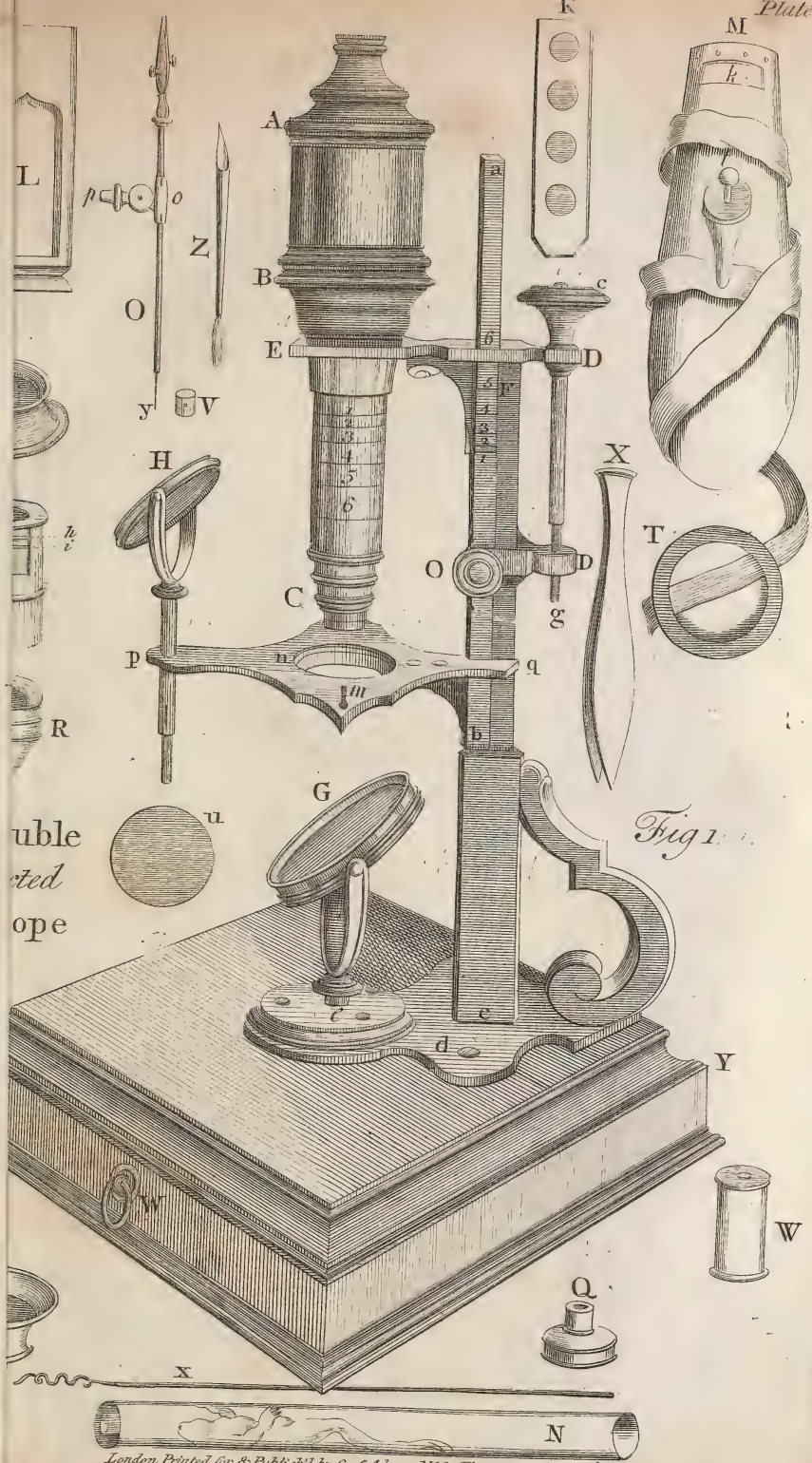
L, a pair of nippers. These are fixed to the stage by the pin R; the steel wire of these nippers slides backwards and forwards in the socket, and this socket is moveable upwards and downwards by means of the joint, so that the position of the object may be varied at pleasure. The object may be fixed in the nippers, stuck on the point, or affixed by a little gum water, &c. to the ivory cylinder N.

O, a small pair of forceps to take up small objects.

P, a brush to clean the glasses.

TO USE ELLIS'S MICROSCOPE.

Take all the parts of the apparatus out of the box; then begin by screwing the pillar A to the cover thereof; pass the pin R of the semicircle which carries the mirror through the hole that is near the bottom of the pillar A; push the stage into the dove-tail at B, slide the pin into the pillar, (see the N. B. above) then pass the bar E through the socket which is at the top of the pin D, and screw one of the magnifying lenses into the ring at F. The microscope is now ready for use; and though the enumeration of the articles may lead the reader to imagine the instrument to be of a complex nature, we can safely affirm, that he will find it



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M^r Ellis's Aquatic Microscope

Pl. 7 B.

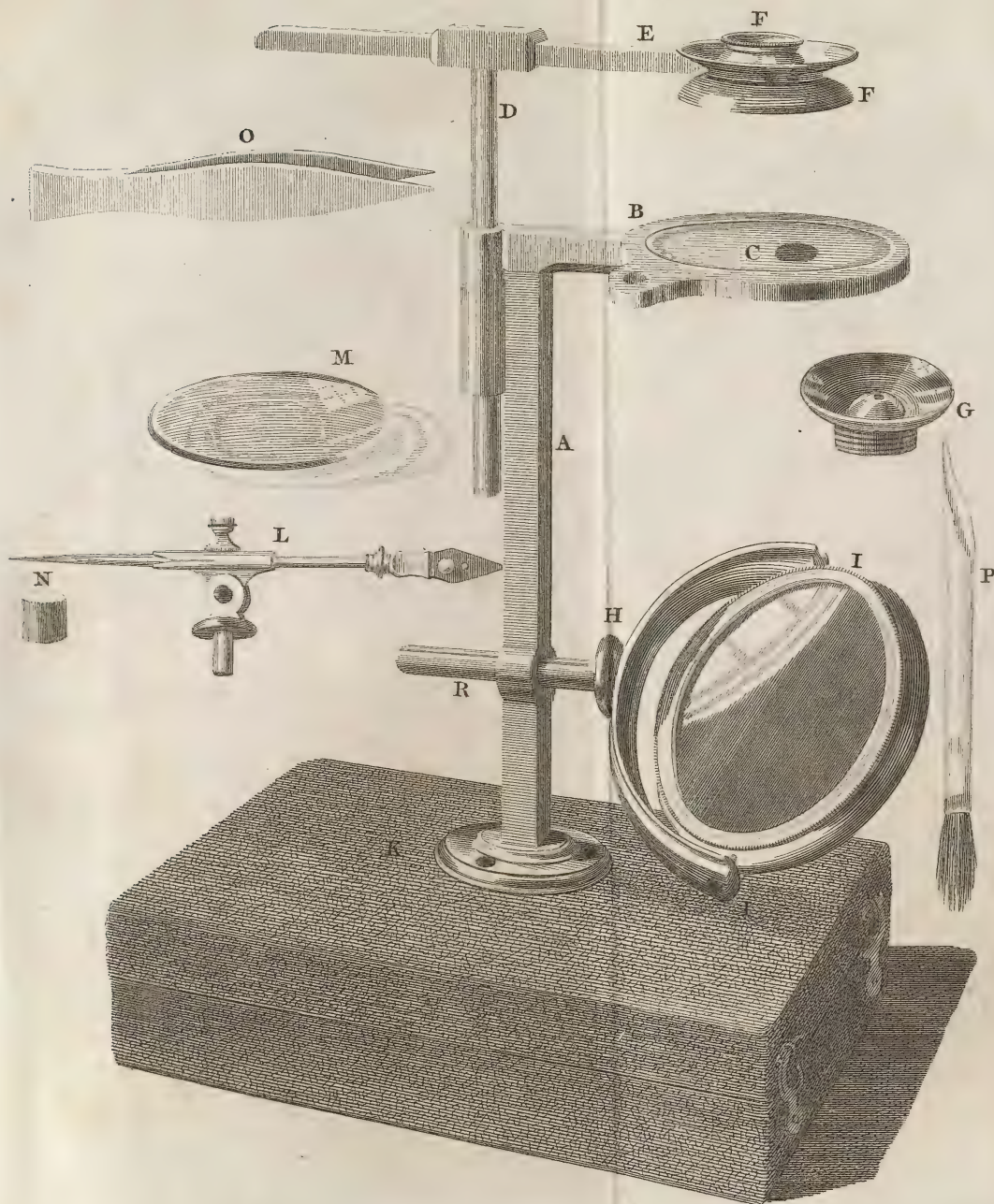


Fig 1

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The Double Constructed Microscope

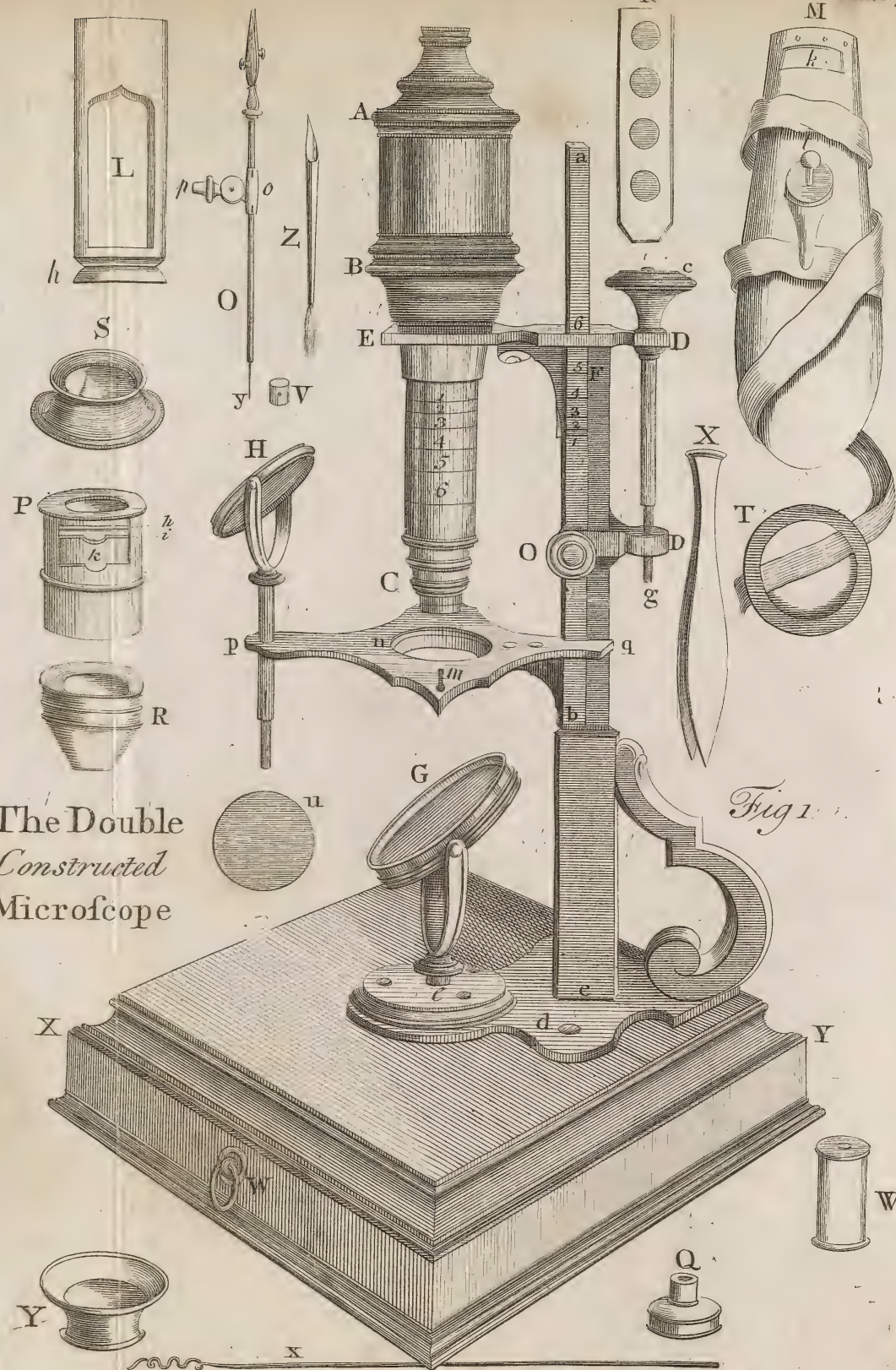


Fig 1

London Printed for & Published by Geo. Adams N^o 60 Fleet Street. May 20th 1787.



it otherwise. The instrument has this peculiar advantage, that it is difficult to put any of the pieces in a place which is appropriated to another.

Let the object be now placed either on the stage or in the nippers L, and in such manner, that it may be as nearly as possible over the center of the stage: bring the speculum F over the part you mean to observe; then throw as much light on the speculum as you can, by means of the mirror IL, and the double motion of which it is capable; the light received on the speculum is reflected by it on the object. The distance of the lens F from the object is regulated by moving the pin D up and down, until a distinct view of it is obtained. The rule which I observe is, to place the lens beyond its focal distance from the object, and then gradually slide it down, till the object appears sharp and well defined. The adjustment of the lenses to their focus, and the distribution of the light on the object, are what require the most attention; on the first the distinctness of the vision depends; the pleasure arising from a clear view of the parts under observation, is due to the modification of the light. No precise rule can be given for attaining accurately these points; it is from practice alone that ready habits of obtaining these necessary properties can be acquired; with the assistance of this no difficulty will be found.

These microscopes are sometimes fitted up with a toothed rack and pinion, for the more ready adjustment of the glasses to their proper focus.

DESCRIPTION OF LYONET'S ANATOMICAL MICROSCOPE,
Fig. 3, Plate VI.

Fig. 3 represents the instrument with which M. Lyonet made his microscopical and wonderful dissection of the chenille de saule, of which a specimen is given in Plate XII. Fig. 1, &c. of this work. This little instrument needs no further recommendation; aided by it, other observers may be enabled to dissect other insects with the same accuracy as M. Lyonet, and thus advance the knowledge of comparative anatomy, by which alone the characteristic, nature, and rank of animals, can be truly ascertained.

AB is the anatomical table, which is supported by the pillar NO; this is screwed on the foot CD. The table AB is prevented from turning round, by means of two steady pins; in this table or board there is a hole G, which is exactly over the center of the mirror EF, that is to reflect the light on the object; the hole G is designed to receive a flat or concave glass, on which the objects are to be placed that you design to examine.

RXZ is an arm formed of several balls and sockets, by which means it may be moved in every possible situation; it is fixed to the board by means of the screw H; the last arm IZ has a female screw, into which a magnifier may be screwed as at Z. By means of the screw H, a small motion may be occasionally given to the arm IZ, for adjusting the lens with accuracy to its focal distance from the object.

Another chain of balls is sometimes used, carrying a lens to throw light upon the object; the mirror is also so mounted, as to be

be taken from it's place at K, and fitted on a clamp, by which it may be fixed to any part of the table A B.

TO USE THE DISSECTING TABLE.

Let the operator set with his left side near a light window ; the instrument being placed on a firm table, the side DH towards the stomach, the observations should be made with the left eye ; this position is well adapted for observing drawing or writing. In dissecting, the two elbows are to be supported by the table on which the instrument rests, the hands resting against the board AB ; in order to give it greater stability, (as a small shake, though imperceptible to the naked eye, is very visible in the microscope) the dissecting instruments are to be held one in each hand, between the thumb and two fore-fingers. Other circumstances will be learnt from practice ; and more will be said on the mode of dissecting small objects in the following chapter.

DESCRIPTION OF DR. WITHERING'S BOTANICAL MICROSCOPE, Fig. 1, Plate VI.

This little instrument is represented at Fig. 1, Plate VI. It consists of three brass plates, A, B, C, which are parallel to each other ; the wires D and E are rivetted into the upper and lower plate, which are by this means united to each other ; the middle plate or stage is moveable on the aforesaid wires, by two little sockets which are fixed to it.

The two upper plates each contain a magnifying lens, but of different powers: one of these confines and keeps in their places the fine point F, the forceps G, and the small knife H.

To use this instrument, unscrew the upper lens, and take out the point, the knife, and the forceps; then screw the lens on again, place the object on the stage, and then move it up or down till you have gained a distinct view of the object, as one lens is made of a shorter focus than the other; and spare lenses, of a still deeper focus, may be had if required. This little microscope is the invention of Dr. Withering, and is described by him in his "Botanical Arrangements." Its principal merit is its simplicity.

COMMON BOTANICAL MICROSCOPE.

This little instrument is represented at Fig. 2, Plate VI. It appears to me preferable to Dr. Withering's, being equally simple, more extensive in its application, and the stage unincumbered; though that of M. Lyonet seems better adapted than either to the purposes of dissection.

A B, a small arm, carrying the two magnifiers, one fixed to the upper part as at B, the other to the lower part of the arm at C; these may be used separately or combined together. The arm A B is supported by the square pillar I K, the lower end of which fits into the socket E of the foot F G; the stage D L is made to slide up and down the square pillar; H, a concave mirror for reflecting light on the object.

To

MICROSCOPICAL ESSAYS.

To use this microscope, place the object on the stage, reflect the light on it from the concave mirror, and regulate it to the focus, by moving the stage nearer to or further from the lens at B. The ivory sliders pass through the stage; other objects may be fixed in the nippers L M, and then brought under the eye-glasses; or they may be laid on one of the glasses which fit the stage.

The apparatus to this instrument consists of three ivory sliders, a pair of nippers, a pair of forceps, a flat glass, and a concave ditto, both fitted to the stage.

BOTANICAL MAGNIFIERS.

Since botany has been cultivated with so much ardor, it has been found necessary to contrive some very portable instrument, by which the botanist might investigate the object of his pursuits, as it rises before him. Figures 7 and 8, Plate VIII. represent two, the most convenient of this kind.

In the case, Fig. 8, are three lenses, *g, h, i*, of different magnifying powers, that all turn up and shut into the case.

Fig. 7 contains also three lenses, *a, b, d*, of different foci, which are all made to turn into the case, and may be used combined or separately.

The three lenses in themselves afford three different magnifying powers; by combining two and two we make three more; the three together make a seventh magnifying power with three
lenses.

lenfes. When the three lenfes are ufed together, it is beft to turn them into the cafe, and look through the hole, as this combined magnifying power is fo great, that it requires to have a portion of the light which falls on the lenfes excluded, in order to attain diftinct vifion. Further, the eye is alfo by this means made to coincide more eafily with the axis of the glaffes.

DESCRIPTION OF A PORTABLE MICROSCOPE AND TELESCOPE,
Fig. 1, 2, 3, 4, 5, 6, Plate VIII.

The telescope is one of thofe which are compofed of feveral fliding drawers or tubes, for the convenience of being put in the pocket; the fliding tubes are made of thin brafs, the outfide tube of mahogany.

The fliding tubes are contrived to flop when drawn out to a proper length, fo that by applying one hand to the outfide tube, and the other hand to the end of the fmalleft tube, the telescope may be at one pull drawn out it's whole length; then any of the tubes (that next the eye is moft generally ufed) may be pushed in gradually while you are looking through, till the object is rendered diftinct to the fight.

To make the tubes flide properly, they all pafs through fhort fprings or tubes; thefe fprings may be unfcrewed from the ends of the fliding tubes by means of the milled edges which project above the tubes, and the tubes taken from each other if required, and the fpring fet clofer if it is too weak.

Fig.

Plate 8.

Fig. 1.

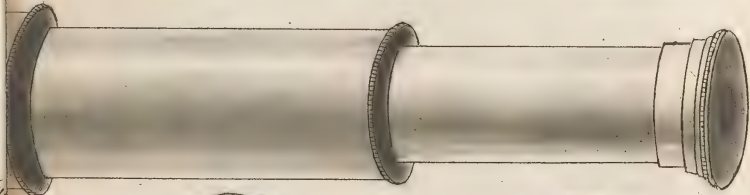
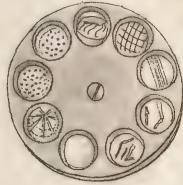


Fig. 7.



Fig. 8.



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Fig. 5 represents the exterior tube of the telescope, which is to be unscrewed from the rest, as it does not make any part of the microscope; the cover *k*, which protects the object-glass, serves also as a box to contain the sliders with the objects, and a small mirror.

Fig. 4 is a view of this cover when taken off: unscrew the top part of it, and the mirror, Fig. 6, may be taken out; unscrew the cover of the lower part, and you will find therein the two circular sliders represented at Fig. 1 and 2.

Fig. 3 represents the three internal tubes of the telescope, which constitute the microscopic part thereof. Draw the tubes out in the manner that is seen in Fig. 3; then on the inside, but at the lower end of the exterior tube, you will find a short tube, which serves as a stage to hold the object and support the mirror; pull this tube partly out, and turn it, so that a circular hole which is pierced in it may coincide with a similar hole in the exterior tube. This tube is represented as drawn out at Fig. 3, the mirror, Fig. 4, placed therein at *LM*, and the transparent slider fixed at *NO*.

Fig. 1 represents the slider with transparent objects.

Fig. 2, that with opaque. They are made of ivory, and turn on a pin at the center; the slit end of this pin fits on the edge of the tube, which is then to be pushed up, so that the lower end of the exterior tube may bear lightly on the upper side of the slider, agreeable to the view which is given at Fig. 3. Now push down the second tube till the milled part falls on the milled edge of the

exterior tube, being careful of the circular hole in the exterior one. Nothing now remains to be done but to adjust for the focus, which is effected by pushing down the tube T V till the object appears distinct.

The instrument may be used in two ways for transparent objects; first, in a vertical position, when the light is to be thrown on the object by the mirror L M; or it may be examined by looking up directly at the light; in the latter case the mirror must be taken away.

In viewing opaque objects the mirror is of no use; as much light as possible must be let fall on them through the circular holes of the tubes.

Any object may be viewed by first pushing the tube I R, and then bringing the tube T to it's focal distance from the object.

A DESCRIPTION OF THOSE PARTS OF A MICROSCOPICAL APPARATUS, WHICH ARE DELINEATED IN Plate IX.

A and B represent the brass cells which contain the magnifiers belonging to the different kinds of compound microscopes. The magnifiers are sometimes contained in a slider like that which is delineated at Fig. 3, Plate V. The lenses of A and B are confined by a small cap; on unscrewing this, the small lens may be taken out and cleaned. The magnifiers A of the lucernal microscope are so contrived, that any two of them may be screwed together, by which means a considerable variety of magnifying power is obtained.

To

To get at the lenses in the slider, Fig. 3, Plate V. take out the two screws which hold on the cover.

C, Plate IX. represents the general form of the slider-holder. It consists of a cylindrical tube, in which an inner tube is forced up by a spring. It is used to receive the ivory or any other slider, in which the transparent objects are placed; these are to be slid between the two upper plates: the hollow part in one of the plates is designed for the glass tubes.

D, the condensing lens and its tube, which fits into the slider-holder C, and may be moved up and down in it. When this piece is pushed up as far as it will go, it condenses the light of a candle, which is reflected on it by the plain mirror of the compound microscope, and spreads it uniformly over the object; in this case it is best adapted to the shallowest magnifiers. If the deeper lenses are used, it should be drawn down, or rather removed further from the object, that it may concentrate the light in a small compass, and thus render it more dense. The condensing lens is sometimes fitted up differently, but the principle being the same, it will be easy to apply it to use, notwithstanding some variations in the mechanism.

E, a brass cone; it fixes under the slider-holder. It is used to lessen occasionally the quantity of light which comes from the mirror to any object.

F, a box, with two flat glasses, which may be placed at different distances from each other, in order to confine a small living insect.

G, a small brass box to hold the silver speculum H.

H, a small silver concave speculum, designed to reflect the light from the mirror on opaque objects; it should only be used with the shallow magnifiers. It is applied in different ways to the compound microscope; sometimes to a tube similar to that represented at X, which slides on the lower part of the body; sometimes it is screwed into the ring of the piece Q; the pin of this generally fits into one of the holes in the stage. When this speculum is used, the slider-holder should be removed.

I, a fish-pan, whereon a small fish may be fastened, in order to view the circulation of the blood; its tail is to be spread across the oblong hole at the smallest end, and tied fast by means of the ribbon-fixed thereto, by shoving the knob which is on the back of it through the slit made in the stage; the tail of the fish may be brought under the lens which is in use.

K, a cylindrical piece, intended for the solar opaque microscope; by pulling back the spiral spring, smaller or larger objects may be confined in it.

L, a long steel wire, with a small pair of pliers at one end, and a steel point at the other; the wire slips backwards or forwards in a spring tube, which is affixed to a joint, at the bottom of which is a pin to fit one of the holes in the stage; this piece is used to confine small objects.

M, a small ivory cylinder that fits on the pointed end of the steel wire L; it is designed to receive opaque objects. Light-coloured

coloured ones are to be stuck on the dark side, and vice versa.

K 2 is a pair of triangular nippers, for taking hold and confining a large object.

M, a convex lens, which fits the stage by means of the long pin adhering to it; it is designed to collect the light from the sun or a candle, and to throw them on any object placed on the stage: this piece is very little used at present.

N, a brass slider, into which is fitted a flat piece of glass, and a brass slider, containing one or two small concave glasses, the others flat; it is designed to confine small living objects, and when used is to be placed between the two upper plates of the slider-holder.

O, a glass tube to receive a small fish, &c.

P represents one of the ivory-sliders, wherein objects are placed between two pieces of talc, and confined by a brass ring.

Q, a piece to hold the speculum H; this piece is generally fitted to the microscopes which are represented at Fig. 1 and 2, Plate IV.

R, a pair of forceps, to take up any occasional object.

S, a camel's hair pencil to brush the dust off the glasses; the upper part of the quill is scooped out, to take up a drop of any fluid, and place it on either of the glasses for examination.

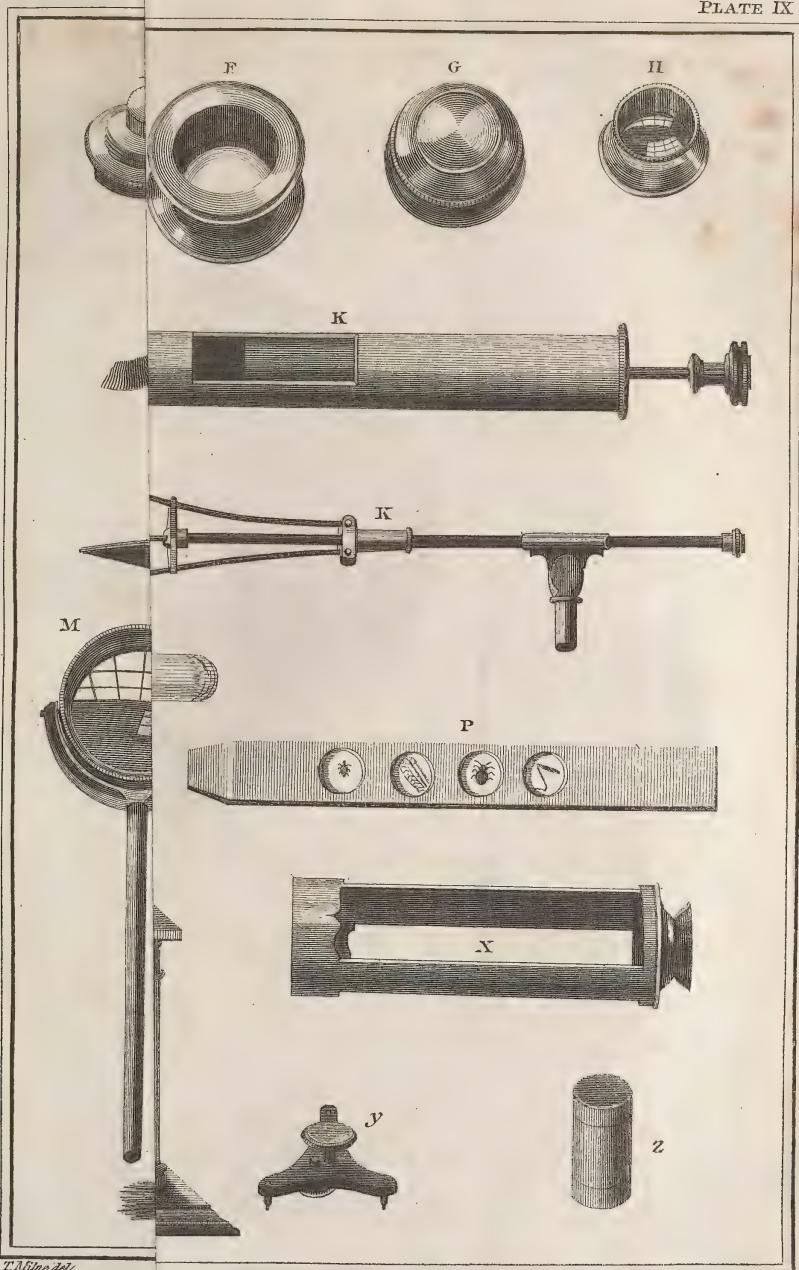
T, an instrument for cutting thin transverse sections of wood. It consists of a wooden base, which supports four brass pillars; on the top of the pillars is placed a flat piece of brass, near the middle of which there is a triangular hole.

A sharp knife, which moves in a diagonal direction, is fixed on the upper side of the afore-mentioned plate, and in such a manner, that the edge always coincides with the surface thereof.

The knife is moved backwards and forwards by means of the handle a. The piece of wood is placed in the triangular trough which is under the brass plate, and is to be kept steady therein by a milled screw which is fitted to the trough; the wood is to be pressed forward for cutting by the micrometer screw b.

The pieces of wood should be applied to this instrument immediately on being taken out of the ground, or else they should be soaked for some time in water, to soften them so that they may not hurt the edge of the knife.

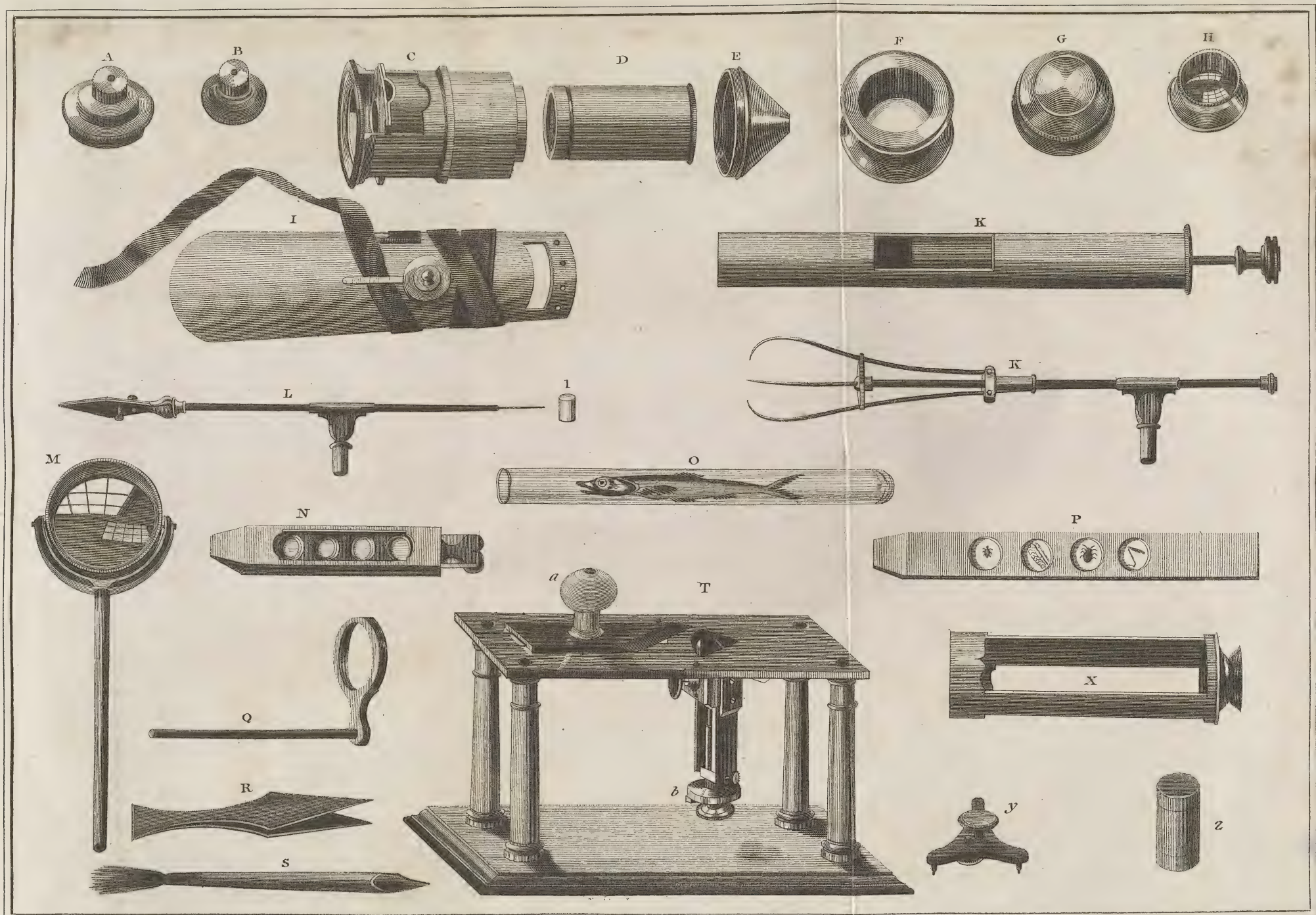
When the edge of the knife is brought in contact with the piece of wood, a small quantity of spirits of wine should be poured on the surface of the wood, to prevent it's curling up; it will also make it adhere to the knife, from which it may be removed by pressing a piece of blotting-paper on it.



T. N. Fibre del.

May 20. 1787.

In London.





Y is an appendage to the cutting engine, which is to be used instead of the micrometer screw, being preferred by some practitioners to it. It is placed over the triangular hole, and kept flat down upon the surface of the brass plate, while the piece of wood is pressed against a circular piece of brass which is on the under side of it.

This circular piece of brass is fixed to a screw, by which its distance from the flat plate on which the knife moves may be regulated.

Z, an ivory box, containing at one end spare talc for the ivory sliders, and at the other spare rings, for pressing the talcs together and confining them to the slider.



C H A P. IV.

GENERAL INSTRUCTIONS FOR USING THE MICROSCOPE,
AND PREPARING THE OBJECTS.

AS the advantages which are obtained from any instrument are considerably increased, if it be used by a person who is master of it's properties, attentive to it's adjustments, and habituated by practice to the minutiae of management, it is the design of this chapter to point out those circumstances which require most the attention of the observer, and to give such plain directions, as may enable him to examine any object with ease; to shew how he may place it in the best point of view, and, if necessary, prepare it for observation.

A small degree of attention will render the observer master of every necessary rule, and a little practice will make them familiar and habitual: the pains he takes to acquire these habits will be rewarded by an increasing attachment to his instrument, and the wonders it displays. Let him only persevere till he has overcome that natural indolence which opposes the advancement of every kind of knowledge, and he will surely find himself most amply recompensed, by the pleasure of a science that has the unlimited treasures of INFINITE WISDOM for the object of it's

researches : and his mind being strengthened by the victory it has gained, will be more keen in perceiving, and more patient in the investigation of truth.

It has long been a complaint,* that many of those who purchase microscopes are so little acquainted with their general and extensive usefulness, and so much at a loss for objects to examine by them, that after diverting their friends some few times with what they find in the sliders, which generally accompany the instrument, or perhaps two or three common objects, the microscope is laid aside as of little further value : whereas no instrument has yet appeared in the world capable of affording so constant, various, and satisfactory an entertainment to the mind. This complaint will, I hope, be obviated by these essays, in which I have endeavoured to make the use of the microscope easy, point out an immense variety of objects, and direct the observer how to prepare them for examination.

The subject treated of in this chapter naturally divides itself into three heads : 1. concerning the necessary preparation and adjustment of the microscope ; the 2nd, treating of the proper quantity of the light, and best method of adapting it to the objects under examination ; the 3d, shewing how to prepare and preserve the various objects, that their nature, organization, and texture, may be properly understood.

Or

* Baker's Microscope made Easy, p. 51.

OF THE NECESSARY PREPARATION OF THE MICROSCOPE
FOR OBSERVATION.

We have in the last chapter explained those particulars that constitute the difference of one microscope from another, and shewn how each instrument is to be used, and how the several parts are to be applied to it. We shall now proceed to give some general directions applicable to every microscope. The observer is therefore supposed to have made himself master of his instrument, and to know how to adapt the different parts of the apparatus to their proper places.

The first circumstance necessary to be examined into is, whether the different glasses belonging to the microscope are perfectly clean or not; if they are not clean, they must be taken out and wiped with a piece of wash leather, taking care at the same time not to foil the surface of the glass with the fingers: in replacing the glasses, you must also be careful not to lay them in an oblique situation.

The object should be brought as near the center of the field of view as possible, for there only will it be exhibited in the greatest perfection.

The eye should be moved up and down from the eye-glass of a compound microscope, till you find that situation where the largest field and most distinct view of the object is obtained. Every person ought to adjust the microscope to his own eye, and not depend upon the situation it was placed in by another.

Care

Care must be taken not to let the breath fall upon the eye-glass, nor to hold that part of the body of the microscope where the glasses are placed with a warm hand, because the damp that is expelled from the metal by the heat will be attracted and condensed by the glasses, and obstruct the sight of the object.

The observer should always begin with a small magnifying power; with this he will gain an accurate idea of the situation and connection of the whole, and will therefore be less liable to form any erroneous opinion, when the parts are viewed separately by a deeper lens. By a shallow magnifier he will also discover those parts which merit a further investigation.

Every object should, if possible, be examined first in that position which is most natural to it: if this circumstance is neglected, very inadequate ideas of the structure of the whole, as well as of the connection and use of the parts, will be formed. If it be a living animal, care must be taken not to squeeze, hurt, or discompose it.

There is a great difference between merely viewing an object by the microscope, and investigating its nature: in the first we only consider the magnified representation thereof, in the second we endeavour to analyse and discover its nature and relation to other objects. In the first case, we receive the impression of an image formed by the action of the glasses; in the second, we form our judgment by investigating this image. It is easy to view the image which is offered to the eye, but not so easy to form a judgment of the things that are seen; an extensive knowledge of the subject, great patience, and many experiments, will be found

R

necessary

necessary for this purpose: for there are many circumstances where the images seen may be very similar, though originating from substances totally different; it is here the penetration of the observer will be exercised, to discover the difference, and avoid error.*

Hence Mr. Baker † cautions us against forming an opinion too suddenly of any microscopic object, and not to draw our inferences till after repeated experiments and examinations of the object, in all lights and various positions; to pass no judgment upon things extended by force, or contracted by dryness, or in any manner out of a natural state, without making suitable allowances.

The true colour of objects cannot be properly determined when viewed through the deepest magnifiers; for, as the pores and interstices of an object are enlarged, according to the magnifying power of the glasses made use of, the component particles of it's substance will appear separated many thousand times farther asunder than they do to the naked eye: it is, therefore, very probable, that the reflection of the light from these particles will be very different, and exhibit different colours.

Some consideration is also necessary in forming a judgment of the motion of living creatures, or even of fluids, when seen through the microscope; for as the moving body, and the space wherein it moves, are magnified, the motion will also be increased.

IF

* Fontana sur les Poisons, vol. ii. p. 245.

† Baker's Microscope made Easy, p. 62.

If an object is so opaque as not to suffer any light to pass through it, as much as possible must be thrown on its upper surface by that part of the apparatus which is peculiarly adapted for opaque objects. As the apertures of deep magnifiers are but small, and consequently admit but little light, they are not proper for the examination of opaque objects: this, however, naturally leads us to our second head.

OF THE MANAGEMENT OF THE LIGHT.

The pleasure arising from a just view of a microscopic object, the distinctness of vision, &c. depend on a due management of the light, and adapting the quantity of it to the nature of the object, and the focus of the magnifier: therefore an object should always be viewed in various degrees of light. For, as Dr. Hooke has well observed, it is difficult to distinguish in some objects between a prominency and a depression, between a shadow and a black stain; and in colour, between a reflection and a whiteness: a truth which the reader will find fully exemplified in the examination of the eye of the libella, and other flies, which will be found to appear exceedingly different in one position of the light from what they do in another.

The brightness of an object depends on the quantity of light; the distinctness of vision, on regulating the quantity to the object; for some will be lost, and drowned, as it were, in a quantity of light that is scarce sufficient to render another visible. A strong light may be thrown on an object various ways; first, by means of the sun and a convex lens; for this purpose, place the microscope about three feet from a southern window; take a deep

convex lens, that is mounted in a semicircle and fixed on a stand, so that it's position may be easily varied; place this lens between the object and the window, so that it may collect a considerable number of the solar rays, and refract them on the object, or the mirror of the microscope. If the light thus collected from the sun is too powerful, it may be tempered, by placing a piece of oiled paper, or a glass lightly greyed, between the object and the lens: by this means, a convenient degree of light may be obtained, and diffused in an equal manner over the whole surface of an object, a circumstance that should be particularly attended to; for if the light be thrown in an irregular manner, that is, larger portions of it on some parts than on others, it will not be distinctly exhibited.

Where the solar light is preferred, it will be found very convenient to darken the room, and to reflect the rays of the sun on the above-mentioned lens, by means of the mirror of a solar microscope fitted to the window-shutter; for by this apparatus the observer will be enabled to preserve the light on his object, notwithstanding the motion of the sun.

Cutting off the adventitious light as much as possible, by darkening the room where you are using the microscope, and admitting the light only through a hole in the window-shutter, or at most keeping one window only open, will also be found very conducive towards producing a distinct view of the object.

As the motion of the sun, and the variable state of our atmosphere, renders solar observations both tedious and inconvenient, it will be proper for the observer to be furnished with a large tin
lanthorn.

lanthorn, made something like the common magic lanthorn, fit to contain one of Argand's lamps.* The lanthorn should have an aperture in the front, that may be moved up and down, and capable of holding a lens; by this a pleasing uniform dense light may be easily procured. The lamp should move on a rod, that it may be readily elevated or depressed. The lanthorn may be used for many other purposes, as for viewing of pictures, exhibiting microscopic objects on a screen, &c.

Many transparent objects are seen best in a weak light; among these we may place the prepared eyes of flies and animalcula in fluids; the quantity of light from a lamp or candle may be lessened by removing the microscope to a greater distance from them, or it may be more effectually lessened by cutting off a part of the cone of rays that fall on the object, either by placing the cone, Fig. E, Plate IX. under the stage, or by forming circular apertures of black paper, of different sizes, and placing either a larger or smaller one on the reflecting mirror, as occasion may require.

There is an oblique situation of the mirrors, and consequently of the light, which is easily discovered by practice, but for which no general rule can be given, that will exhibit an object more beautifully and more distinctly than any other position, shewing the surface, as well as those parts through which the light is transmitted.

A better

* The lamp should not be of the fountain kind, because the rarefaction of the air in the lanthorn will often force the oil over.

A better view of most objects is obtained by a candle, or lamp, than by day-light; it is more easy to modify the former than the latter, and to throw it on the object with different degrees of density. From what has been said, the reader will have observed the importance of being able to examine the object in the greatest variety of positions and appearances, which cannot be effected with equal convenience by any microscope but the improved lucernal.

OF THE PREPARATION OF OBJECTS FOR THE MICROSCOPE.

In the preparation of objects, no man was more successful nor more indefatigable than Swammerdam, in minutely anatomizing, in patient investigation, and in curiously exhibiting the minute wonders of creation; he stands unrivalled, far exceeding all those that preceded, as well as those which have succeeded him. Deeply impressed and warmly animated by the amazing scenes that he continually discovered, his zeal in pursuit of truth was not to be abated by disappointment, or alarmed by difficulty; and was never contented till he had attained a rational and clear idea of the organization of the object, whose structure he wished to explore.

We have only to regret that we are ignorant of the methods he employed. To discover these, the great Boerhaave examined with a scrupulous attention all the letters and manuscripts of Swammerdam, and has communicated the result of his researches, which, though but small, may enable us to form some idea of this great labourer in the field of science.

For

For dissecting of small insects he had a brass table, which was made by that excellent artist S. Muffchenbrock; to this table were affixed two brass arms, moveable at pleasure to any part of it. The upper portion of these arms was constructed so as to have a slow vertical motion, by which means the operator could readily alter their height, as he saw most convenient to his purpose; the office of one of these arms was to hold the little bodies, and that of the other to apply the lens or microscope.

His microscopes, or lenses, were of various foci, diameters, and sizes, from the least to the greatest, and the best that could be procured in regard to the exactness of the workmanship, and transparency of the substance. His way was, to begin his observations with the smallest magnifiers; and from thence proceed by degrees to the greatest. By nature and use he was so incomparably dexterous in the management of these instruments, that he made every observation subservient to the next, and all tend to confirm each other, and complete the description.

His chief art seems to have been in constructing very fine scissars, and giving them an extreme sharpness: these he made use of to cut very minute objects, because they dissected them equally; whereas knives and lancets, let them be ever so fine and sharp, are apt to disorder delicate substances, as in going through them, they generally draw after and displace some of the filaments. His knives, lancets, and styles, were so very fine, that he could not see to sharpen them without the assistance of a magnifying glass; but with them he could dissect the intestines of bees with the same accuracy and distinctness that the most celebrated anatomist does those of large animals. He was particularly dexterous

in the management of small glass tubes, which were no thicker than a bristle, and drawn to a very fine point at one end, but thicker at the other. These he made use of to shew and blow up the smallest vessels discovered by the microscope, to trace, distinguish, separate their courses and communications, or to inject them with very subtil coloured liquors.

He used to suffocate the insects in spirit of wine, in water, or spirit of turpentine, and likewise preserved them for some time in these liquids; by which means he kept the parts from putrefying, and consequently collapsing and mixing together; and added to them besides such strength and firmness, as rendered the dissections more easy and agreeable. When he had divided transversely with his fine scissars the little creature he intended to examine, and had carefully noted every thing that appeared without further dissection, he then proceeded to extract the viscera in a very cautious and leisurely manner, with other instruments of great fineness; first taking care to wash away and separate, with very fine pencils, the fat with which insects are very plentifully supplied, and which always prejudice the internal parts before it can be extracted. This operation is best performed upon insects while in the nympha state.

Sometimes he put into water the delicate viscera of the insects he had suffocated; and then shaking them gently, he procured himself an opportunity of examining them, especially the air vessels, which by this means he could separate from all the other parts whole and entire, to the great admiration of all those who beheld them; as these vessels are not to be distinctly seen in any other manner, or indeed seen at all without damaging them, he
often

often made use of water, injected by a syringe, to cleanse thoroughly the internal parts, then blew them up with air and dried them, by which means he rendered them durable, and fit for examination at a proper opportunity. Sometimes he has examined with the greatest success, and made the most important discoveries, in insects that he had preserved in balsam, and kept for years together in that condition. Again, he has frequently made punctures in other insects with a very fine needle, and after squeezing out all their moisture through the holes made in this manner, he filled them with air, by means of very slender glass tubes, then dried them in the shade, and last of all anointed them with oil of spike, in which a little rosin had been dissolved, by which means they retain their proper forms a long time. He had a singular secret, whereby he could so preserve the nerves of insects, that they used to continue as limber and perspicuous as ever they had been.

He used to make a small puncture or incision in the tail of worms, and after having gently and with great patience squeezed out all their humours, and great part of their viscera, he then injected them with wax, so as to give and continue to them all the appearance of healthy vigorous living creatures. He discovered that the fat of all insects was perfectly dissolvable in oil of turpentine; thus he was enabled to shew the viscera plainly; only after this dissolution he used to cleanse and wash them well and often in clean water. He frequently spent whole days in thus cleansing a single caterpillar of its fat, in order to discover the true construction of this insect's heart. His singular sagacity in stripping off the skin of caterpillars, that were upon the point of spinning their cones, deserves particular notice. This he effected,

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by letting them drop by their threads into scalding water, and suddenly withdrawing them; for by this means the epidermis peeled off very easily; and when this was done, he put them into distilled vinegar and spirit of wine, mixed together in equal portions, which, by giving a proper firmness to the parts, gave him an opportunity of separating them, with very little trouble, from the exuviae, or skins, without any danger to the parts; so that by this contrivance, the nymph could be shewn to be wrapped up in the caterpillar, and the butterfly in the nymph. Those who look into the works of Swammerdam, will be abundantly gratified, whether they consider his immense labour and unremitted ardour in these pursuits, or his wonderful devotion and piety. On one hand, his genius urged him to examine the miracles of the great Creator in his natural productions; whilst on the other, the love of that same all-perfect Being rooted in his mind, struggled hard to persuade him that God alone, and not the creatures, were worthy of his researches, love, and attention.

M. Lyonet always drowned first those insects he intended to anatomize, as by this means he was enabled to preserve both the softness and transparency of the parts. If the insect, &c. is very small, ex. gr. one-tenth of an inch, or a little more in length, it should be dissected in water, on a glass which is a little concave; if after a few days there is any fear that the insect will putrefy, it should be placed in weak spirit of wine, instead of water. In order to fix the little creature, it must be suffered to dry, and then be fastened by a piece of soft wax; after which it may be again covered with water.

Larger

Larger objects require a different process; they should be placed in a small trough of thin wood; the bottom of a common chip box will answer very well, by surrounding the edge of it with soft wax, to keep in the water or spirit of wine. The insect is then to be opened, and if the parts are soft like those of a caterpillar, they should be turned back and fixed to the trough by small pins; the pins are to be set by a pair of small nippers; the skin being stretched at the same instant by another pair of finer forceps, the insect must then be placed in water, and dissected therein, and after two or three days it should be covered with spirits of wine, which should be renewed occasionally; by this means the subject is preserved in perfection, and its parts may be gradually unfolded, without any other change being perceived than that the soft elastic parts become stiff and opaque, and some others lose their colour.

M. Lyonet used the following instruments in his curious dissection of the chenille-de saule. As small a pair of scissars as could be made, the arms long and fine; a small and sharp knife, the end brought to a point; a pair of forceps, the ends of which had been so adjusted, that they would easily lay hold of a spider's thread or a grain of sand. But the most useful instruments were two fine steel needles, fixed in small wooden handles, about $2\frac{3}{4}$ of an inch in length.

An observation of Dr. Hooke's may be very useful, if attended to, for fixing objects intended to be designed by the microscope. He found no creature more troublesome to draw than the ant or pismire, not being able to get the body quiet in a natural posture. If, when alive, its feet were fettered with wax or glue, it would

so twist and twine it's body, that it was impossible any way to get a good view of it; if it was killed, the body was so small, that the shape was often spoiled before it could be examined. It is the nature of many minute bodies, when their life is destroyed, for the parts to shrivel up immediately; this is very observable in many small plants, as well as in insects; the surface of these small bodies, if porous, being affected by almost every change of the air; and this is particularly the case with the ant. But if the little creature is dropped in well rectified spirit of wine, it is immediately killed; and when taken out, the spirit of wine evaporates, leaves the animal dry and in it's natural posture; or at least so constituted, that you may easily place it with a pin in what posture you please.*

Having thus given a general account of the methods used by Swammerdam and Lyonet, in their examination and dissection of insects, we shall proceed to shew how to prepare several of their parts for the microscope, beginning with the WINGS. Many of these are so transparent and clear, as to require no previous preparation; but the under wings of those that are covered with elytra or crustaceous cases, being constantly folded up when at rest, they must be unfolded before they can be examined by the microscope: for this purpose, a considerable share of dexterity, and some patience is necessary; for the natural spring of the wings is so strong, that they immediately fold themselves again, except they are carefully prevented.

One of the most curious and beautiful wings of this kind is that of the EARWIG, of which we have given a drawing, Plate XIV.

Fig.

* Hooke's Micrographia, p. 203.

Fig. 1. When expanded it is a tolerably large wing, yet folds up under a case not one-eighth part of it's size. It is very difficult to unfold this wing, on account of it's curious texture. They are best opened immediately after the insect is killed. Hold the earwig by the thorax, between the finger and thumb; then with a blunt pointed pin endeavour gently to open it, by spreading it over the fore-finger, gradually sliding at the same time the thumb over it. When the wing is fully expanded, separate it from the insect by a sharp knife, or a pair of scissars. The wing should be pressed for some time between the thumb and finger before it be removed; it may then be placed between two pieces of paper, and again pressed for at least an hour: after which, it may be put between the tales without any danger of folding up again.

The wings of the notonecta, and other water insects, as well as most species of the grylli, require equal care and delicacy with that of the earwig to display them properly.

THE WINGS OF BUTTERFLIES AND MOTHS are covered with very minute scales or feathers, that afford a beautiful object for the microscope; near the thorax, the shoulder, the middle of the wing, and the fringes of the wings, they are generally intermixed with hair. The scales from one part, also, often differ in shape from those of another; they may be first scraped off or loosened from the wing with a knife, and then brush them into a piece of paper with a camel's hair pencil; the scales may be separated from the hairs with the assistance of a common magnifying glass.

The proboscis of insects, as of the gnat, the tabanus, &c. requires much attention, and considerable care, to be dissected properly

properly for the microscope; and many must be prepared before the observer decides upon the situation and shape of the parts; he will often also be able to unfold in one specimen some parts that he can scarce discover in another. It is well known that the COLLECTOR OF THE BEE forms a most beautiful object; a figure of it is given in Plate XIII. Fig. 3. In it is displayed a most wonderful mechanism, admirably adapted to collect and extract the various sweets from flowers, &c. To prepare this, it should first be carefully washed with spirit of turpentine, by which means it will be freed from the unctuous and melliferous particles which usually adhere to it; when dry, it must be again washed with a camel's hair pencil, to disengage and bring forward the small hairs which form one part of its microscopic beauty.

The case which encloses THE STING OF THE BEE, the wasp, and the hornet, are so hard, that it is very difficult to extract them without breaking or otherwise injuring them. It will be found, perhaps, the best way to soak the case and the rest of the apparatus for some time in spirit of wine or turpentine, then lay it on a piece of clean paper, and with a blunt knife draw out the sting, holding the sheath by the nail of the finger, or by any blunt instrument; great care is requisite to preserve the feelers, which when cleaned add much to the beauty of the object.

THE EYES OF THE LIBELLULA and different flies, of the lobster, &c. are first to be cleaned from the blood and other extraneous matter, they should then be soaked in water for some days, after which you may separate one or two skins from the eye, which, if they remain, render it too opaque and confused;

some care is, however, requisite in this separation, otherwise the skin may be made too thin, so as not to enable you to form an accurate idea of it's organization.

The exuviae of insects are in general a very pleasing object, and require but little preparation. If they are curled or bent up, keep them in a moist atmosphere for a few hours, and they will soon become so relaxed that you may extend them with ease to their natural positions. The steam of warm water answers the purpose very well.

The beard of the *lepas anitifera* is to be soaked in clean soft water, and frequently brushed while wet with a camel's hair pencil; it may then be left to dry: after which it must be again brushed with a dry pencil, to disengage and separate the hairs, which are apt to adhere together. A picture of this object is represented in Plate XIII. Fig. 1.

To view the MUSCULAR FIBRES, take a very thin piece of dried flesh, and lay it upon a slip of glass, and moisten it with warm water; when this is evaporated, the vessels will appear plain and more visible, and by repeated macerations the parts may be further disengaged.

To examine fat, brains, and other similar substances, we are advised by Dr. Hooke to render the surface smooth, by pressing it between two thin plates of flat glass; by which the substance will be made much thinner and more transparent; otherwise the parts lying thick one upon the other, it appears confused and indistinct.

Some

Some substances are, however, so organized, that if their peculiar form is altered, the parts we wish to discover are destroyed; such as nerves, tendons, muscular fibres, pith of wood, &c. many of these are best to be examined while floating in some convenient transparent fluid. For instance, very few of the fibres of any of the muscles can be discovered when they are viewed in the open air; but if placed in water or oil, great part of their wonderful fabric may be discovered. If the thread of a ligament is viewed in this manner, it will be seen to consist of an indefinite number of smooth round threads lying close together.

Objects of an elastic nature should be pulled or stretched out while they are under the microscope, that the texture and nature of those parts, whose figure is altered by being thus pulled out, may be more fully discovered.

To examine BONES with the microscope. These should first be viewed as opaque objects; afterwards, by procuring thin sections, they should be looked at as if transparent. The sections should be cut in all directions, and be well washed and cleaned; a degree of maceration will be useful in some cases. Or the bones may be put in a clear fire till they are red hot, and then taken out; by this means the bony cells will appear more conspicuous and visible, being freed from extraneous matter.

To examine the PORES OF THE SKIN. First, cut or pare off with a razor as thin a slice as possible of the upper skin; then cut a second from the same place; apply the last to the microscope.

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THE SCALES OF FISH should be soaked in water for a few days, and then be carefully rubbed, to clean them from the skin and dirt which may adhere to them.

To procure the scales of the eel, which are a great curiosity, and the more so as the eel was not known to have any till they were discovered by the microscope. Take a piece of the skin of the eel that grows on the side, and while it is moist spread it on a piece of glass, that it may dry very smooth; when thus dried, the surface will appear all over dimpled or pitted by the scales, which lie under a sort of cuticle or thin skin; this skin may be raised with the sharp point of a penknife, together with the scales which will then easily slip out, and thus you may procure as many as you please.*

On the lizard, the guana, &c. are two skins; one of these is very transparent, the other is thicker and more opaque; by separating these we procure two beautiful objects.

THE LEAVES of many trees, and some plants, when dissected, form a very pleasing object. To dissect them, take a few of the most perfect leaves you can find, and place them in a pan with clean water; let them remain three weeks or a month without changing the water; then take them up, and try if they feel very soft, and appear almost rotten; if so, they are sufficiently soaked. You are then to lay them on a flat board, and holding them by the stalk, draw the edge of a knife over the upper side of the leaf, which will take off most of the skin; turn the leaf, and do

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* Martin's Micrographia Nova, p. 29.

the same with the under side. When the skin is taken off on both sides, wash out the pulpy matter, and the fibres will be exhibited in a beautiful manner. By flitting the stalk you may separate the anatomized leaf into two parts. The skins that are peeled from the fibres will also make a very good object. The autumn is the best season for the foregoing operation, as the fibres of the leaves are much stronger at that season, and less liable to break.

Ores and minerals should all be carefully washed and brushed with a small brush, to remove any extraneous matter that may adhere to them. Shells may be ground down on a hone, by which their internal structure will be displayed.

TO VIEW THE CIRCULATION AND EXAMINE THE PARTICLES OF THE BLOOD. The principal point the observer must aim at, in order to view the circulation of the blood, is to procure those small animals or insects that are most transparent, that by seeing through them he may be enabled to discover what passes within them. The particular kinds best adapted for the purpose will be enumerated in the descriptive catalogue at the end of this work.

If a small eel is used for this purpose, it must be cleansed from the slime which covers it; after which it may be put either in the fish-pan, or a glass tube filled with water, and then placed under the microscope. If the eel is small enough, the circulation may be viewed in the most satisfactory manner. Leeuwenhoek has given, in his 112th epistle, an accurate description of the blood-vessels in part of the tail of an eel. The same figure may also be seen in my father's Treatise on the Microscope. The tail of any
other

other small fish may be applied in the same manner, or tied on a slip of flat glass, and be thus laid before the microscope. Flounders; eels, and gudgeons, are to be had almost at any time in London.—N. B. By filling the tube with water, when an eel is used, it will in a great measure prevent the sliminess of the eel from soiling the glass.

To view the particles of the blood, take a small drop of it when warm, and spread it as thin as possible upon a flat piece of glass. By diluting it a little with warm water, some of the larger globules will divide from the smaller, and many of them will be subdivided into smaller ones: or a little drop of blood may be put into a capillary tube of glass, and be then presented before the microscope. Mr. Baker advises the mixing the blood with a little warm milk, which, he says, will cause the unbroken particles to be very distinctly seen; but the most accurate observer of these particles was Mr. Hewson, and he says, they have been termed globules with great impropriety, being in reality flat bodies. When we consider how many ingenious persons have been employed in examining the blood with the best microscopes, it appears surprising that the figure of the particles should be mistaken; but the wonder is lessened when we reflect how many obvious things are overlooked, till our attention is particularly directed towards them; and besides, the blood in the human subject, and in quadrupeds, is so full of these particles, that it is with great difficulty they can be seen separate until the blood is diluted. It was by discovering a proper method to effect this that Mr. Hewson was indebted for his success. He diluted the particles with serum, in which they would remain undissolved, and as he could dilute them to any degree with the serum, he could easily

examine the particles distinct from each other; ex. gr. take a small quantity of the serum of the human blood, and shake a piece of crassamentum in it, till it is coloured a little with the red particles; then with a soft hair pencil spread a little of it on a piece of thin glass, and place this glass under the microscope, in such a manner as not to be quite horizontal, but rather higher at one end than the other; by which means, the serum will flow from the higher to the lower extremity, and as it flows some of the particles will be found to swim on their flat sides, and will appear to have a dark spot in the middle: others will turn over from one side to the other, as they roll down the glass.

An apparatus has been described by several authors for viewing the circulation of the blood in the mesentery of a frog; by this instrument curiosity may be gratified; but it is at the expence of humanity, and that without any probability of extending the bounds of science, or promoting the good of mankind. No rational excuse can be given for depriving a poor creature of it's life, the greatest boon that nature can bestow, or even to put it in pain, but an object of utility; he who does from hence procure benefits for the higher orders of animated beings, may be permitted to exert the power which he possesses over the inferior orders of life. But he greatly errs, if he thinks these powers may be used to gratify wanton curiosity, or the sports of an inordinate fancy.

“ ————— God, when he charg'd the Jew
T' assist his foe's down-fallen beast to rise;
And when the bush-exploring boy, that seiz'd
The young, to let the parent bird go free,

Prov'd

Prov'd he not plainly that his meaner works
 Are yet his care, and have an int'rest all—
 ALL in the universal Father's love?"

* * * * *

"I would not enter on my list of friends
 (Tho' grac'd with polish'd manners and fine sense,
 Yet wanting sensibility) the man
 Who needlessly sets foot upon a worm.
 An inadvertent step may crush the snail
 That crawls at ev'ning in the public path;
 But he that has humanity, forewarn'd,
 Will tread aside, and let the reptile live."

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"A necessary act incurs no blame:
 Not so when held within their proper bounds,
 And guiltless of offence, they range the air,
 Or take their pastime in the spacious field:—
 There they are privileg'd. And he that hunts,
 Or harms them there, is guilty of a wrong."

COWPER'S POEMS, vol. 2, b. vi.

OF ANIMALCULA IN INFUSIONS, &c.

These require little or no preparation. The first object is to procure them, the second to render them visible by the microscope. A few observations, however, may be of use. Many drops of water may be examined before any can be found; so that if the observer be too hasty, he may be easily disappointed, though other parts of the same water may be fully peopled by them.

The surface of infused liquors is generally covered with a thin pellicle, which is easily broken, but acquires thickness by standing; the greatest number of animalcula are generally to be found in this superficial film.

In some cases it is necessary to dilute the infusions; but this is always to be done with distilled water, and that water should be examined in the microscope before it is made use of: the neglect of this precaution has been a source of many errors.

Animalcula are in general better observed when the water is a little evaporated, as the eye is not confused, nor the attention diverted by a few objects. To separate one or two animalcula from the rest, place a small drop of water on the glass near that of the infusion; make a small neck, or gutter, between the two drops with a pin, which will join them together; then the instant you perceive that an animalculum has traversed the neck or gutter, and entered the drop, cut off the communication between the two drops.

To

To procure the eels in paste, boil a little flour and water, till it comes to the consistence of such a paste as is used by the book-binders; expose it to the air in an open vessel, and beat it together from time to time, to prevent the surface thereof growing hard or mouldy: after a few days it will turn four; then, if it be examined with attention, you will find myriads of eels on the surface.

To preserve these eels all the year, you must keep the surface of the paste moist, by putting a little water or fresh paste from time to time to the other. Mr. Baker advises a drop or two of vinegar to be put into the paste now and then. The continual motion of the eels, while the surface is moist, will prevent the paste getting mouldy. Apply them to the microscope upon a slip of flat glass, first putting on it a drop of water, taken up by the head of a pin, for them to swim in.

To make an infusion of pepper. Bruise as much common black pepper as will cover the bottom of an open jar, and lay it thereon about half an inch thick; pour as much soft water in the vessel as will rise about an inch above the pepper. The pepper and water are then to be well shook together; after which they must not be stirred, but be left exposed to the air for a few days, when a thin pellicle will be formed on the surface of the water, containing millions of animalcula.

The observer should be careful not to form a judgment of the nature, the use, and the operations of small animalcula, from ideas which he has acquired by considering the properties of larger animals: for, by the assistance of glasses, we are introduced as it were

were into a new world, and become acquainted not only with a few unknown animals, but with numerous species thereof, which are so singular in their formation and habits, that without the clearest proofs even their existence would not be credited; and while they afford fresh instances of the Creator's power, they also give further proofs of the limits and weakness of the human understanding.

DIRECTIONS FOR FINDING, FEEDING, AND PRESERVING
THE POLYPES.

These little animals are to be found upon all sorts of aquatic plants, upon branches of trees, pieces of board, rotten leaves, stones, and other substances that lie in the water; they are also to be found upon the bodies of several aquatic animals, as on the water-snail, on several species of the monocus, &c. they generally fix themselves to these by their tail, so that it is a very good method when you are in search of polypes, to take up a great many of these substances, and put them in a glass full of water. If there be any polypes adhering to these, you will soon perceive them stretching out their arms, especially if the glass is let stand still for a while without moving it; for the polypes, which contract themselves on being first taken out of the water, will soon extend themselves again when they are at rest.

They are to be sought for in the corners of ditches, puddles, and ponds, being generally driven into these with the pieces of wood or leaves to which they have attached themselves. They may, therefore, be sought for in vain at one period, in a place where at another you shall find them in abundance. They are

more easily perceived in a ditch when the sun shines on the bottom, than at another time. They are seldom to be met with in winter: about the month of May they begin to appear and increase.

They are generally to be found in waters which move gently; for neither a rapid stream, nor stagnant waters, ever abound with them. As they are always fixed to some substance by their tails, and are very rarely loose in the water, taking up water only can signify but little; a circumstance which has probably been the cause of much disappointment to those who have searched for them.

The green polypes are generally about half an inch long when stretched out; those of the second and third sort are between three quarters of an inch and an inch in length; though some are to be found at times which are an inch and a half long.

Heat and cold has the same effect upon these little creatures, that it has upon those of a larger size. They are animated and enlivened by heat, whereas cold renders them faint and languid; they should therefore be kept in such a degree of heat, that the water may not be below temperate.

It is convenient for many experiments to suspend a polype from the surface of the water. To effect this, take a hair pencil in one hand, and hold a pointed quill in the other; with the pencil loosen the polype from the receiver in which it is kept, and gradually raise it near the top of the water, so that the anterior end may be next the point of the pencil; then lift it out of

the water, and keep it so for a minute; after which, thrust the point of the pencil, together with the anterior end, by little and little under water, until no more than about half the tenth of an inch of the polype's tail remains above it's surface; at this instant, with the pointed quill remove that part of the polype from the pencil which is already in the water, and at the same time blowing against the polype, it will be loosened, and remain out of the water.

When the polypes were first discovered, Mr. Trembley had some difficulty to find out that food which was proper for them; but he soon discovered, that a small species of the millepede answered the purpose very well: the pulices aquatiles have also been recommended. The small red worms, which are to be found on the mud-banks of the Thames, particularly near the shores, answer the purpose also; they are easily found when the tide is out, when they rise in such swarms on the surface of the mud, that it appears of a red colour. These worms are an excellent food for the polype. If a sufficient quantity is gathered in November, and put into a large glass full of water, with three or four inches of earth at the bottom, you will have a supply for the polypes all the winter. They may also be fed with common worms, with the larva of gnats and other insects, and even with butchers meat, &c. if it be cut small enough.

River, or any soft water, agrees with them; but that which is hard and sharp prevents their thriving, and generally kills them in a few days. The worms with which they are fed should be always cleansed before you feed the polypes with them.

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The polypes are commonly infested with little lice; from these it is necessary to free them, in order to preserve your polypes in a good state of health. They may be cleansed from the lice by rubbing them with a hair pencil; this cannot be easily done, without they have affixed themselves to some substance: so that if they are suspended from the surface of the water, you must endeavour to get them to fix themselves to a piece of packthread; when they are fastened thereto, you may then rub them with a hair pencil, without loosening them from the thread.

The lice which torment the polype are not only very numerous, but they are also very large relative to it's size: they may be said to be nearly as large with respect to them, as a common beetle is to us. If they are not rubbed off, they soon cover their bodies, and in a little time totally destroy them.

To preserve the polypes in health, it is also necessary often to change the water they are kept in, and particularly after they have done eating; it is not sufficient to pour the water off, all the polypes should be taken out, and the bottom and sides of the vessel rubbed from the slimy sediment adhering thereto; this is caused by their fæces, and is fatal to them if not cleaned away. The fæces often occasion a species of mortification, which increases every day; it's progress may be stopped by cutting off the diseased part. To take them out, first loosen their tails from the sides or bottom of the glass; then take them up one by one, with a quill cut in the shape of a scoop, and place them in another glass with clean water; if they cling to the quill, let it remain a minute or two in water, and they will soon disengage themselves.

They are preserved best in large glaffes, that hold three or four quarts of water; for in a glafs of this fize the water need not be renewed fo often, particularly if the fæces are taken out from time to time with the feathered end of a pen, to which it readily adheres; and further, the trouble of feeding each individual is in fome meafure faved, as you need only throw in a parcel of worms, and let the polypes divide them for themfelves.

To obfervè with accuracy the various habitudes, pofitions, &c. of this little animal, it will be neceffary to place fome of them in narrow cylindrical glaffes; then, by means of the microfcope, Fig. 3, Plate VI. you may obferve it exerting all it's actions, of life with eafe and convenience; the facility with which the lens of the fore-mentioned microfcope may be moved and placed in any direction, renders it a moft convenient inftrument for examining any object that requires to be viewed in water.

It is alfo very proper to dry fome of them, and place them between talcs in a slider; this however requires fome dexterity, and a little practice; tho' when executed with fuccefs, it fully rewards the pains of the obferver. Chufe a proper polype, and put it in a fmall concave lens, with a drop of water; when it is extended, and the tail fixed, pour off a little of the water, and then plunge it with the concave into fome fpirit of wine contained in the bowl of a large fpoon; by this it is instantly killed, the arms and body contracting more or lefs; rub it gently, while in fpirits, with a fmall hair pencil, to cleanfe it from the lice.

The difficulty now begins; for the parts of the polype, on being taken out of the fpirits, immediately cling together, fo that
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it is not practicable to extend the body, and separate the arms on the talc, without tearing them to pieces: so that the only method is, to adjust them upon the talc while in the spirits; this may be done by slipping the talc under the body of the polype, while it lies in the spirits, and displaying it's arms thereon by the small hair pencil and a pair of nippers; then lift the talc, with the polype upon it, out of the spirits; take hold of it with the nippers in the left hand, dip the pencil in the spirits with the right hand, and therewith dispose of the several parts, that they may lie in a convenient manner, at the same time brushing away any lice that may be seen upon the talc; now let it dry, which it does in a little time, and place the talc carefully in the hole of the slider. To prevent the upper talc and ring pressing on the polype, you must cut three pieces of cork, about the bigness of a pin's head, and the depth of the polype, and fix them by gum in a triangular position, partly on the edges of the said talc, partly to the sides of the ivory hole itself; the upper talc may then be laid on these corks, and pressed down by the ring as usual.*

OF VEGETABLES.

I wish I could give the reader a satisfactory account of all the preparations which are requisite to fit for the microscope the objects of the vegetable kingdom. Dr. Hill is the only writer who has handled this subject. I shall, therefore, extract from his "Treatise on the Construction of Timber," what he has said; this, together with the improvements I have made on the cutting

* Baker on the Polypes.

cutting engine, will enable the reader to pursue the subject, and extend it further, both for his own pleasure, and the advantage of the public.

THE MANNER OF OBTAINING THE PARTS OF A SHOOT
SEPARATE.

In the beginning of April, take a quantity of young branches from the scarlet oak, and other trees. These are first cut into lengths, of the growth of different seasons; and then part are left entire, part split, and the rest quartered. In this state they are put into a wicker basket, with large openings, or of loose work, and a heavy stone is put in with them: a rope is tied to the handle of the basket, and it is thrown into a brook of running water: at times it is taken up, and exposed a little to the air; it is frequently shook about under water, to wash off filth; and once in ten days the sticks are examined.

By degrees the parts loosen from one another; and by gentle rubbing in a basin of water, just warmed, they will be so far separated, that a pencil brush will perfect the business, and afford pieces of various size, pure, distinct, and clean. One part will in this way separate at one time, and another at another; but by returning the sticks to the water, and repeating the operation, in the course of four or five weeks, every part may be obtained distinct. They are best examined immediately; but if any one wishes to preserve them for repeated inquiries, it may be done in this manner: dissolve half an ounce of alum in two quarts of water; drop the pieces thus separated, for a few moments, into this solution, then dry them upon paper, and put them up in

vials of spirit of wine. Nothing but spirit of wine can preserve these tender bodies.

TO PREPARE THE RIND FOR OBSERVATION.

As the vessels of the rind are of different diameters in various trees, though their construction and that of the blebs is perfectly the same in all, it will be best to chuse for this purpose the rind of a tree wherein they are largest. The rind of the ash-leaved maple is finely suited. A piece of this may be obtained of two inches long, and will very successfully answer the intention. Such a piece being prepared without alum or spirit, but dried from the water in which it had been macerated, it is to be impregnated with lead in the following manner, to shew the apertures by their colour.

Diffolve one dram of fugar of lead in an ounce and a half of water; filter this through paper, and pour it into a tea-cup. Clip off a thin slice of what was the lower end of the piece of rind as it grew on the tree, and plunge it near an inch deep into the liquor; keep it upright between two pieces of stick, so that one half or more may be above the water: whelm a wine and water glass over the tea-cup, and set the whole in a warm place. When it has stood two days, take it out, and clip off all that part which was in the liquor, and throw it away.

The circumstances here mentioned, trivial as they seem, must be attended to: the operation will not succeed, even if the covering-glass be omitted; it keeps a moist atmosphere about the rind, and makes it's vessels supple.

While

While this is standing, put into a bason two ounces of quick lime, and an ounce of orpiment; pour upon them a pint and a half of boiling water; stir the whole together, and when it has stood a day and night, it will be fit for use. This is the liquor probatorius vini of some of the German chemists: it discovers lead when wines are adulterated with it, and will shew it any where.

Put a little of this liquor in a tea-cup, and plunge the piece of rind half-way into it.

In the former part of this experiment, the vessels of the rind have been filled with a solution of lead, that makes of itself no visible alteration in them; but this colourless impregnation, when the orpiment lixivium gets to it, becomes of a deep brown; the vessels themselves appear somewhat the darker for it; but these dots, which are real openings, now are seen to be plainly such, the colour being perfectly visible in them, and much darker than in the vessels. This object must be always viewed dry.

If a piece of the rind, thus impregnated, be gently rubbed between the fingers, till the parts are separated, we shall be able in one place or other to get a view of the vessels all round, and of the films which form the blebs between them.

Every part of the rind, and every coat of it, even the interstitial place between it's innermost coat and bark, are filled with a fine fluid. The very course and progress of the fluid may be shewn in this part, even by an easy preparation: only that different rinds must be sought for this purpose, the vessels in some being

being larger than in others. Repeated trials have shewn me that the whole progress may be easily marked in the three following kinds, with only a tincture of cochineal.

Put half an ounce of cochineal, in powder, into half a pint of spirit of wine; set it in a warm place, and shake it often for four days; then filter off the clear tincture. Put an inch depth of this into a cup, and set upright in it pieces of the rind of ash, white willow, and osier, prepared as has been directed, by maceration in water; for in that way one trouble does for a hundred kinds. Let an inch of the rinds also stand up out of the tincture. After twenty-four hours take them out, clip off the part which was immersed in the fluid, and save the rest for observation.

TO PREPARE THE BLEA.

Cut the pieces in a fit season, either just before the first leaves of spring, or in the midsummer shooting time. Then we see all the wonders of the structure; the thousands of mouths which open throughout the course of these innumerable vessels, to pour their fluid into the interstitial matter.

These vessels, which are in nature cisterns of sap for the feeding the growth of the whole tree, are so large, that they are capable of being filled with coloured wax, in the manner of the vessels in anatomical injections; and this way they afford pleasing objects for the microscope, and give excellent opportunities of tracing their course and structure.

A METHOD OF FILLING THE SAP VESSELS OF PLANTS.

A great many shoots of the scarlet and other oaks are to be taken off in the spring; they must be cut into pieces of about two inches in length, and immediately from the cutting they must drop into some warm rain water: in this they are to stand twenty-four hours, and then be boiled a little. When taken out, they are to be tied on strings, and hung up in a place where the air passes freely, but the sun does not shine. When they are perfectly dry, a large quantity of green wax, such as is used for the seals of law deeds, is to be gently melted in an earthen pipkin set in water; the water to be heated and kept boiling. As soon as the wax runs, the sticks are to be put in, and they are frequently to be stirred about. They must be kept in this state about an hour, and then the pipkin is to be taken out of the water, and set upon a naked fire, where it is to be kept with the wax boiling for two or three hours; fresh supplies of the same wax being added from time to time.

After this it is to be removed from the fire, and the sticks immediately taken out with a pair of nippers; when they are cold, the rough wax about them is to be broken off. Both ends of each stick are to be cut off half an inch long, and thrown away, and the middle pieces saved. These are then to be cut in smaller lengths, smoothed at the ends with a fine chissel, and many of them split in various thicknesses.

Thus are obtained preparations, not only of great use, but of a wonderful beauty. Many trees this way afford handsome objects as well as the oak; and in some, where the sap vessels are few,

above the surface of the glass. When it is so disposed, hold it as level as you can over the clear part of a fire that is not too fierce, or over the flame of a candle, at a distance proportionable to the degree of heat it requires, (which experience only can direct) and watch it very carefully till you discover the saline particles beginning to gather and look white, or of some other colour, at the extremities of the edges; then having adjusted the microscope before-hand for its reception, armed with the fourth glass, which is the fittest for most of these experiments, place it under your eye, and bring it exactly to the focus of the magnifier; and after running over the whole drop, fix your attention on that side where you observe any increase or pushing forwards of crystalline matter from the circumference towards the center.

This motion is extremely slow at the beginning, unless the drop has been over-heated, but quickens as the water evaporates, and in many kinds, towards the conclusion, produces configurations with a swiftness inconceivable, composed of an infinity of parts, which are adjusted to each other with an elegance, regularity, and order, beyond what the exactest pencil in the world, guided by the ruler and compass, can ever equal, or the most luxuriant imagination fancy.

When action once begins, the eye cannot be taken off, even for a moment, without losing something worth observation; for the figures alter every instant, till the whole process is over; and in many sorts, after all seems at an end, new forms arise, different entirely from any that appeared before, and which probably are owing to some small quantity of salt of another kind, which the other separates from, and leaves to act, after itself has done; and
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in some subjects three or four different sorts are observable, few or none being simple and homogeneous.

When the configurations are fully formed, and all the water evaporated, most kinds of them are soon destroyed again by the moisture or action of the air upon them; their points and angles lose their sharpness, become uneven and defaced, and moulder as it were away; but some few are permanent, and by being inclosed between glasses, they may be preserved months or even years.

It happens oftentimes that a drop of a saline solution can hardly be spread on the slip of glass, by reason of the glass's smoothness, but breaks into little globules, as it would do were the surface greasy: the way to prevent this is, by rubbing the broken drop with your finger over the glass, so as to leave the glass smeared with it; on which smeared place, when dry, another drop of the solution may be spread very easily in what form one pleases.

It sometimes happens, that when a heated drop is placed properly for examination, the observer finds he can distinguish nothing; which is owing to saline steams that rise from the drop cover, and obscure the object glass, and therefore must immediately be wiped away with a soft cloth or leather.

In all examinations by the microscope of saline solutions, even though made in the day-time, you must use a candle; for the configurations being exceedingly transparent, are rendered much more distinguishable by the brown light a candle affords, than by

the more white and transparent day-light; and besides, either by moving the candle or turning the microscope, such light may be varied or directed just as the subject requires.

It may be also proper to take notice, that no kinds of microscopes are fit for these observations, but such as have an open stage, whereon the slips of glass, with the liquor upon them, may be placed readily, and in a perfect horizontal position; and moreover, where they can be turned about freely, and without disordering the fluid.



C H A P. V.

OF INSECTS IN GENERAL.

NATURAL history has been more cultivated in the present century than in all those which have preceded it. Many men, of the first rank in literature, have not disdained to become labourers in the vast field which this science offers every day to the eyes of an accurate and attentive observer. The animal, the vegetable, and the mineral kingdoms, have been examined with the greatest care; and that confusion and perplexity, which, from a view of the immense variety of individuals which each kingdom contained, it seemed natural to apprehend, has been removed, by introducing systematic order into this branch of science; by which means the various individuals have been distributed into classes and genera, and we are now enabled to form distinct and accurate ideas of them. To the same systematic plan, and the nicety of discrimination which arises from it, we are indebted for the discovery and description of many new species in each kingdom.

Amidst the numerous objects which crowd in upon the natural historian, and engage his attention, insects have not been neglected; and though they are the most numerous of the animal tribe, and for the most part very small, yet the knowledge of their nature

nature and wonderful œconomy has been cultivated with unremitting ardour. Some authors have confined themselves to divide and separate them into various classes, and describe their characteristic differences : others have been employed in tracing their habits of life, or in exploring the wonderful mechanism of their frame and structure ; so that the nature, habits, and many peculiarities of their state of life, are now well known.

In number, singularity of appearance, and variety of form, insects exceed every other part of animated nature. Earth, air, and water, are filled with hosts thereof, a far greater part of which are invisible to the naked eye ; but amongst all this variety, we perceive the same regularity, and can trace the footsteps of that love and wisdom which so strongly marks every work of God. In contemplating the works of the Creator, we shall always find his wisdom and his love in pages written by his own eternal hand, in characters legible to every eye.

After an attentive examination of the nature and fabric of both the least and largest animals, I cannot (says the truly great and most excellent Swammerdam) but allow the less an equal, perhaps a superior, degree of dignity. Whoever duly considers the conduct and instinct of the one, with the manners and actions of the other, must acknowledge all are under the direction and controul of a supreme and particular intelligence ; which, as in the largest it extends beyond the limits of our comprehension, escapes our researches in the smallest. If, while we dissect with care the larger animals, we are filled with wonder at the elegant disposition of their limbs, the inimitable order of their muscles, and the regular direction of their veins, arteries, and nerves ; to
what

what an height is our astonishment raised, when we discover all these parts arranged in the least, in the same regular manner. How is it possible but what we must stand amazed, when we reflect that those little animals, whose bodies are smaller than the point of the dissecting knife, have muscles, veins, arteries, and every other part common to the larger animals? Creatures so very diminutive, that our hands are not delicate enough to manage, nor our eyes sufficiently acute to see them.

All beings are perfect, considered in themselves: they all answer one end. The determinations or qualities of each being are the means relative to this end. Those means which are of an exalted nature answer a nobler or higher purpose. The measure of perfection consists in the relation which every being bears to the whole.

When considered with respect to the Creator, all creatures are upon a level; and yet, as creatures, even the most despicable bear such relation to their Creator, as to make them highly valuable to their fellow-creatures, who are themselves only valuable by sharing and partaking of the Divine influence. As the harmony and infinity of the eternal Artist are impressed on all his works, and as outwardly we can find no bounds, so inwardly we can find no end of art and beauty. "Let us then not slight or deem that little, in which immensity is so conspicuous; or that trivial, in which there is such a manifestation of infinite wisdom and power:"* but let us rather

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" Muse

* Brooke's *Universal Beauty*, a poem.

————“ Muse upon his skill displayed;
 (Infinite skill) in all that he has made!
 To trace in nature's most minute design,
 The signature and stamp of pow'r divine;
 Contrivance intricate, express'd with ease,
 Where unassisted sight no beauty sees;
 The shapely limb, and lubricated joint,
 Within the small dimensions of a point;
 Muscle and nerve miraculously spun,
 His mighty work, who speaks and it is done,
 Th' invisible in things scarce seen reveal'd,
 To whom an atom is an ample field.
 To wonder at a thousand insect forms,
 These hatch'd, and those resuscitated worms,
 New life ordain'd, and brighter scenes to share,
 Once prone on earth, now buoyant upon air.”*

The name of insect has been appropriated to these small animals on account of the sections or divisions in the bodies of the greater number of them, from whence the parts seem to be joined together by a kind of neck. It is perhaps impossible to find any general term that shall embrace the whole genera of insects, as many circumstances must be described before we can attain an exact notion of these animals and their constitution.

Insects are by most writers considered as divided into four principal parts; the caput or head, the thorax or trunk, the abdomen or belly, and artus or limbs: a perfect knowledge of these

* Cowper's Poems, vol. I. p. 261.

these parts, and their several subdivisions, is requisite for those who are desirous of forming accurate ideas of these little animals, or who wish to arrange them in their proper classes.

THE HEAD is affixed to the thorax by a species of articulation or joint; it is the principal seat of the senses, and contains the rudiments of the brain; * it is furnished with a mouth, eyes, antennæ, a forehead, a throat, and stemmata. In the greater part of insects the head is distinctly divided from the thorax, but in others it coalesces with it. The head of some insects is very large in proportion to their bodies; the proportion between the head of the same insect is not always the same; in the caterpillars with horny heads it is generally small before they moult or change their skin, but much larger after each moulting. The hardness of the exterior part of the head prevents its growth before the change, it is consequently, relative to the body, very small; but when the insect is disposing itself for the change, the internal substance of the head retires inwards to the first ring of the neck, where it has room to expand itself; so that when the animal quits the skin, we are surprised with a head twice the former size: and as the insect neither eats nor grows while the head is forming, there is this further circumstance to be remarked, that the body and the head have each their particular time of growth. While the head expands and grows, the body does not grow at all; when the body increases, the head remains of the same size, without any change. The heads of all kinds of insects form very pleasing as well as most diversified objects for the opaque microscope.

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THE

* Fabricius *Philosophia Entomologica*, p. 18.

THE MOUTH is a part of the insect to which the naturalist will find it necessary to pay a very particular attention: Fabricius goes so far as to assert, that without a thorough knowledge of the mouth, its form, and various appendages, it will be impossible ever to discriminate with accuracy one insect from another. In the structure of the mouth considerable art and wisdom is displayed: the diversity in the figure is almost as great as the variety of species. It is usually placed in the fore part of the head, extending somewhat downwards; in the chermes, coccus, and some other insects, it is placed under the breast. Some insects have their mouths armed with strong jaws, with which they bruise and tear their food: however fine and delicate these organs may appear, they are really hard, and in some species sufficiently strong to pierce the hardest wood. Others are furnished with a kind of tube or tongue, at one time moveable, at another fixed: with this they suck the juices of the flowers. In some again the tongue is so short as to appear to us incapable of answering the purpose for which it was formed, and the oestri appear to have no mouth.

The rostrum, or proboscis, is the mouth drawn out to a rigid point. In many insects of the hemiptera class it is bent downward towards the breast and belly.

The jaws are generally two in number, sometimes four, and at others more; they are placed in an horizontal direction: the inner edge, in some insects, is serrated, or furnished with small teeth.

The tongue is in general a taper and compact instrument, used by the insect to extract the alimentary juices on which it feeds:
some

some can extend or contract it; others roll up their's with dexterity; in some it is inclosed in a sheath, with the pointed end of which they pierce the substances which contain their food, and then extract the juice with their tongue; in many it is placed in a groove under the belly; taper and spiral in the butterfly; tubular and fleshy in the fly; in some it is long, and in others short, but in all affording a fund of amusement for the microscope.

M. De Geer * has given us an account of a very curious circumstance concerning the tongue of the papillon de faules. † Having cut off the tongue from the butterfly, almost as soon as it was emancipated from the chrysalis, it moved and rolled itself up at intervals for a considerable time: an hour after it had been cut off, it repeated the same motions, recommencing them every time it was touched. The same effect does not follow if the butterfly has been freed from the chrysalis a few days.

The structure of THE EYE is, in all creatures, a most admirable piece of mechanism, but in none more so than in those of insects: there is no part of these small creatures which exhibits more clearly the prodigious art with which they are organized, and shews how many wonders escape the natural sight of man. The eyes are very different in different species, varying in number, situation, connection, figure, and simplicity of construction. The greater part have two eyes, but in the monocus they approach so near to each other as to appear like one; the gyrimus has four eyes, the scorpion six, the spider eight, and the scolopendra three.

The

* De Geer, Mémoires pour servir à L'Histoire des Insectes, tom. I. p. 77.

† Papilio Antiopa, Lin. Syst. Nat. p. 776, N° 165.

The eyes are generally convex; they have no eye-brows, the outer tunic is hard and transparent, having no external motion, the genus of cancri or crabs excepted. The eyes of the greater number appear, when examined by the microscope, to be cut into a multitude of little planes or facets, like the facets of a diamond, having to the naked eye the appearance of net-work. Each of these small facets is supposed to possess the powers and properties of an eye. Leeuwenhoek counted 3181 of these facets in the cornea of a beetle, 8000 in those of a fly. As the eyes of insects are immovable, they would have lost sight of many objects, if their eyes had been framed like those of other animals; but by means of their multiplied eyes, they can easily view surrounding objects: nor is it at all improbable, that, as objects do not appear double to our eyes, but that they are strengthened, and many false appearances are corrected by the use of both; so the numerous inlets to sight in an insect may increase their field of view, augment the intensity of the light, and be productive of other advantages, of which we can form no conception. The eyes of insects differ in colour, some being found of every colour, and of inexpressible beauty and brightness.

The antennæ are fine and slender horns, consisting of several articulations, moveable in various directions. They are beautiful in form, of a delicate structure, and are placed in the fore part of the head: they vary in different insects, not only in their shape, their length, their bulk, but also in the number of their articulations. The antennæ of the male insect generally differ from those of the female: they form one of the most distinguishing characteristics of insects, and one of the means of judging to what genus they belong. The greatest number of

insects have only two antennæ; the oniscus, the pagurus, and astacus have four; indeed Fabricius gives six to the latter.* Of the use they are to these little animals, or the end of the Creator in forming them, we are altogether ignorant: some writers have conjectured that they were the organs of smell and hearing; others have supposed that they were appropriated to a feeling more delicate than our own, and sensible to the least motion or disturbance in the ambient fluid in which they move: several insects cover their eyes with them when they take their rest. They are characterized by naturalists under the following names:

SETACEOUS are those that, like a bristle, grow gradually taper towards their point or extremity.

FILIFORM, thread shaped, and of an uniform thickness.

MONILIFORM; these are of a regular thickness, but consist of a series of knobs, like a necklace of beads.

CLAVATED, formed like a club, increasing gradually from the base to the extremity.

CAPITATED; these are also formed like a club, but the last articulation is larger than the rest, finishing with a kind of capital or head.

FISSILES; these are like the former, only that the head is divided into different parts or laminæ.

PERFOLIATE;

* Fabricius Philosophia Entomologica, p. 19.

PERFOLIATÆ; in these the head is divided horizontally, but the laminæ are connected by a kind of thread passing through their center.

PECTINATÆ; these have several lateral appendages, and appear like a feather.

ARISTATÆ, such as have a lateral hair, which is either naked, or furnished with smaller hairs.

Besides the foregoing terms, the antennæ are called short (*bre-viores*) when they are shorter than the body; *mediocres*, or middling, when they are of the same length; and *longiores*, when they are longer.

Near the mouth there is also a species of small filiform articulated antennæ, called the PALPI, or feelers; they are generally four in number, sometimes six; they are placed under and at the sides of the mouth, which situation, together with their size, sufficiently distinguish them from the antennæ; they are in continual motion, the animal thrusting them in every matter, as a hog would it's nose, when in search of food. Some have supposed them to be a kind of hand to assist in holding the food when it is near the mouth.

THE FOREHEAD occupies the upper part of the head, between the eyes, the mouth, and the thorax.

THE STEMMATA, or crown, three elevated shining hemispheric spots resembling eyes, and placed upon the upper part of the head, as in most of the hymenoptera class.

THE

THE TRUNK is situated between the head and the abdomen; the legs and wings are inserted into it; but in order to distinguish the parts thereof more easily, it is divided into the thorax, scutellum, and sternum.

THE THORAX is the upper part of the trunk; it is of various shapes and proportions; the sides and back of it are often armed with points.

THE SCUTELLUM, or escutcheon, is the posterior part of the thorax, and is generally of a triangular form; though it adheres to the thorax, yet it is easily distinguished from it, by its figure, its use, and often by an intervening suture; it appears designed to assist in expanding the wings when the insect is going to fly.

THE STERNUM is situated on the inferior part of the thorax; it is pointed behind in some species, and bifid in others.

THE ABDOMEN contains the stomach, the intestines, the air vessels, the ovary, &c. it is affixed to the thorax, and in most insects distinct from it, forming the posterior part of the body, being generally composed of rings or segments, by which the insect can lengthen or shorten it, or even move it in different directions. In some species it seems to be formed but of one piece. The upper part of the abdomen is called the tergum, the under part the venter; the anus is the posterior part of the abdomen.

THE SPIRACULA are small oblong oval holes or pores; that are placed singly, one on each side of every ring of the abdomen;

men; through these the insect is supposed to breathe: this singular circumstance in their respiration forms another peculiar character of insects.

THE LIMBS, or the organs used by the insect for moving it's body, and for defending itself, are the tail, the sting, the feet, the wings, the halteres or poisers.

THE TAIL terminates the abdomen, and is constructed in a wonderful manner for answering the purposes for which it is formed, namely, to direct the motion of the insect, to serve as an instrument of defence, or for depositing the eggs; the figure and size thereof varying in each genus and it's families. In some it is simple, *simplex*, and yet capable of being extended or drawn back at pleasure. In others, *elongata*, elongated. Setaceous, shaped like a bristle; *trifeta*, with three appendages like bristles; in some it is forked, *furcata*; and in others it is furnished with a pair of forceps, *forcipata*; in the blatta and others it is *foliosa*, or like a leaf. In the scorpion and panorpa it is *telifera*, furnished with a sting. Further particulars may be obtained from the Philosophia Entomologica of Fabricius.

ACULEUS, or sting, an instrument with which insects wound and instil a poison; the sting generally proceeds from the under part of the last ring of the belly: in some it is sharp and pointed, in others formed like a saw. It is used by many insects both as an offensive and defensive weapon; by others it is only used to pierce the substances where they mean to deposit their eggs.

PEDES,

PEDES, THE FEET. These are admirably adapted for their intended service, to give the most convenient and proper motion, and from the variety in their construction, their various articulations, &c. furnish the microscopic observer with a great many curious and interesting objects: the most general number is six; some have eight, as the spider; the crab has ten; the oniscus fourteen; the julus has from seventy to one hundred and twenty on each side. The legs of those insects that have not more than ten, are affixed to the trunk; while those that exceed that number have part fixed to the trunk, the rest to the abdomen.

The legs of insects are generally divided into four parts. The first, which is usually the largest, is called the *femur*; the second, or *tibia*, is joined to the former, and is commonly of the same size throughout, and longer than the femur; this is followed by the third part, which is distinguished by the name of *tarsus*, or foot; it is composed of several joints, the one articulated to the other, the number of the rings varying in different insects: the tarsus is terminated by the *unguis*, or claw.

The writers on natural history, in order to render their descriptions clear and accurate, have given several names to the legs of insects, from the nature of the motions produced by them.

Thus *cursorii*, from that of running; these are the most numerous.

The *saltatorii*, those that are used for leaping.

The *natatorii*, those that serve as oars for swimming. The thighs of the *saltatorii* are remarkably large, by which means they have considerably more strength and power for leaping. The feet of the *natatorii* are flat, and edged with hairs; thus have a proper surface to strike against the water, as in the *dytiscus*, *notonecta*, &c.

Such feet as have no claws are termed *MUTICI*. The *chelæ*, or claws, are an enlargement of the extremity of the fore feet, each of which is furnished with two lesser claws, which act like a thumb and finger, as in the crab.

The under part of the feet, in some insects, is covered with a kind of brush or sponge, by which they are enabled to walk with ease on the most polished substances, and in situations from which it would seem that they must necessarily fall.

“ They tread the ceiling, an inverted floor,
And from it's precipice depend secure.”

Many insects can only move the thigh in a vertical direction; while others can move it in various directions. The progressive motion of insects, and the various methods employed to effect it, will be found a very curious and important subject, and well worthy the attention of the natural historian. The mechanic will not find it lost labour if he bestows some time on the same subject. Very little has been done on this head, and that principally by Mr. de Reaumur, in his excellent *Memoires*; and by M. Weifs, in a memoir published in the *Journal de Physique* for 1771. The reader may also consult *Borelli de Motu Animalium*.

Motion.

Motion is one of the principal phænomena of nature, and as it were the soul of our system; and is as admirable in the smallest animal as in the universe at large. It may not be amiss just to notice here, that there are some insects of the beetle kind, which contradict an assertion of Borelli's, that an animal puts in action each foot on one side before it moves those on the opposite side; whereas these employ in walking the two most distant feet on the same side, and the middle foot on the opposite; a method which is firm and natural.

THE WINGS, those organs by which the insect is enabled to fly; some have only two, others are furnished with four, two on each side; these are in some of the same size, in others the superior ones are much larger than the inferior. The variety in the form and structure of the wings is almost infinite; the beauty of their colouring, the art with which they are connected to the body, the curious manner in which some are folded up, the fine articulations provided for this purpose, by which they are laid up in their cases when out of use, and yet ready to be extended in a moment for flight; together with the various ramifications, by which the nourishing juices are circulated, and the wing strengthened, afford a fund of rational investigation highly entertaining, exhibiting, particularly when examined by the microscope, a most wonderful display of divine wisdom and power. The more delicate and transparent wings are covered and protected by ELYTRA, or cases, which are generally hard and opaque, often highly polished, adorned with ornamental flutings, and studded with brilliants. The wings of moths and butterflies are mostly farinaceous, covered with a fine dust, that occasions those beautiful colours with which they are so elegantly painted; for
stripped.

stripped of these, the wing is transparent and colourless. By the assistance of the microscope, we discover that this dust is a regular assemblage of organized scales, which will be more particularly described hereafter. A few of these, as seen in the microscope, are exhibited in Plate 16, Fig. F E H I.

The following names are made use of to describe the different kinds of wings. They are first distinguished, with respect to their surfaces, into SUPERIOR and INFERIOR. The part next the head is called the ANTERIOR part, that nearest the tail the POSTERIOR part. THE INTERIOR part is that next the abdomen; THE EXTERIOR part is the outermost edge.

Those wings are termed FLICATILES, which are folded when the insect is at rest, as in the wasp.

PLANÆ, those which are incapable of being folded.

ERECTÆ, whose superior surfaces are brought in contact when the insect is at rest, as in the ephemera, papiliones, &c.

PATENTES, if they are extended horizontally when the insect is at rest, as in the phalænæ geometræ.

INCUMBENTES, those insects which, when they are not in motion, cover horizontally with their wings the superior part of the abdomen.

DEFLEXÆ; these are also incumbentes, but not horizontally, the outer edges declining towards the sides.

REVERSÆ are also deflexæ, with this addition, that the edges of the inferior wing project from under the anterior part of the superior one.

DENTATÆ, with scolloped edges.

CAUDATÆ; in these some of the fibres of the wing are extended beyond the margin into a kind of tail.

RETICULATÆ, when the veins or membranes of the wings put on the appearance of net-work.

The wings are further distinguished by their ornaments, being painted with spots (*maculæ*), bands (*fasciæ*), streaks (*strigæ*): when these are extended lengthways, they are called lines (*linæ*); and if with dots, *punctæ*; one or more rings are termed eyes, *ocellus*; if the spots are shaped like a kidney, they are termed *stigmata*.

The elytra, or crustaceous cases of the wings, are extended when the insect flies, and shut when it rests, forming a longitudinal suture down the middle of the back; they are of various shapes, and are distinguished by the following names:

ABREVIATA, when they are shorter than the abdomen.

TRUNCATA, when the extremity terminates in a transverse direct line.

SERRATA,

SERRATA, having the external margin edged with teeth or notches.

SPINOSA, when the exterior surface is covered with small sharp points.

SCABRA, when it is very rough.

STRIATA, marked with slender longitudinal furrows.

PORCATI, having sharp longitudinal ridges.

SULCATI, with deep furrows.

HEMELYTRA, when the cases are neither so hard as the elytra, nor so delicate as the transparent wing.

Under the wings of most insects, which have only two, there is a small head placed on a stalk, frequently under a little arched scale; these are called HALTERES, poisers; they appear to be rudiments of the hinder wings: it has been supposed that they serve to keep the body in equilibrio when the insect is flying.

The bodies of insects are covered with a hard skin, which answers the purpose of an internal skeleton, and is one of the distinguishing characters of an insect. All quadrupedes, birds, and fishes, have an internal skeleton of bones to which the muscles are fixed; but the whole interior body of an insect is composed of soft flesh, and the muscles are affixed to the exterior skeleton



Fig. 6.

Fig. 5.

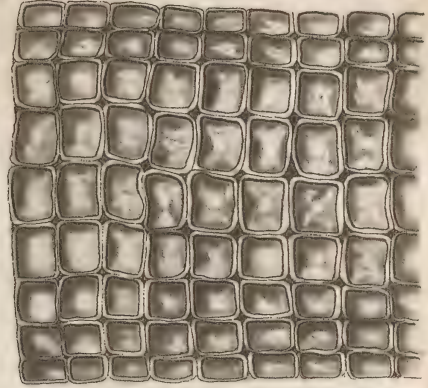


Fig. 9.

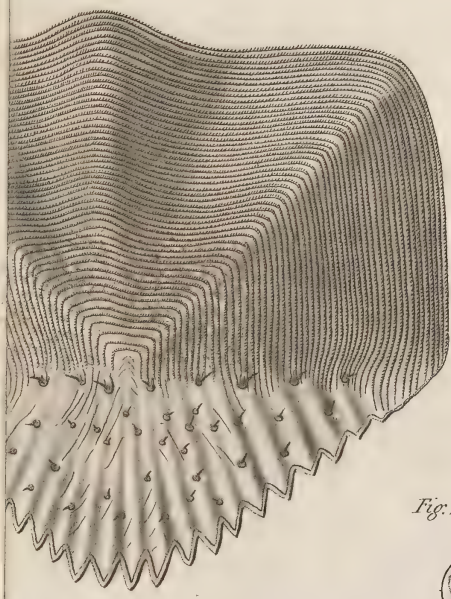


Fig. 10.



Fig. 1.

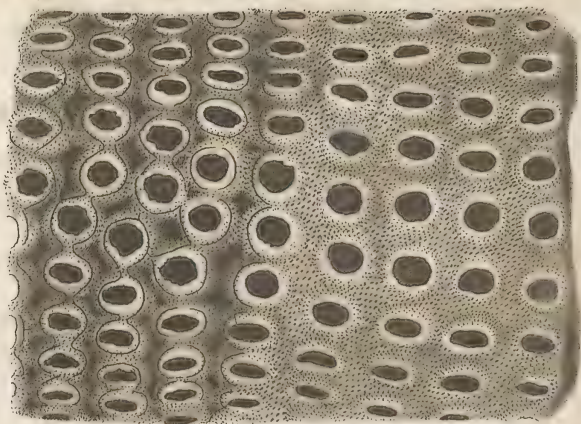


Fig. 2.



Fig. 4.



Fig. 3.

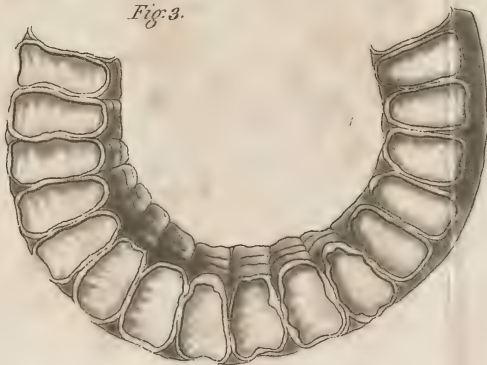


Fig. 6.



Fig. 5.

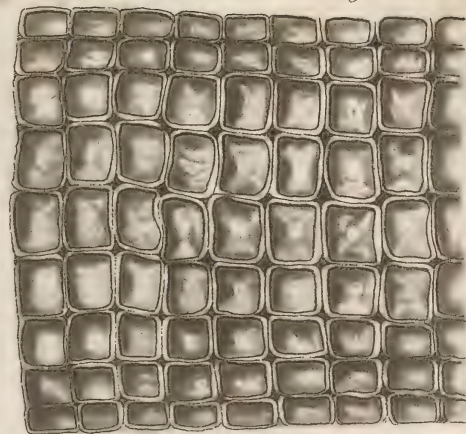


Fig. 7.

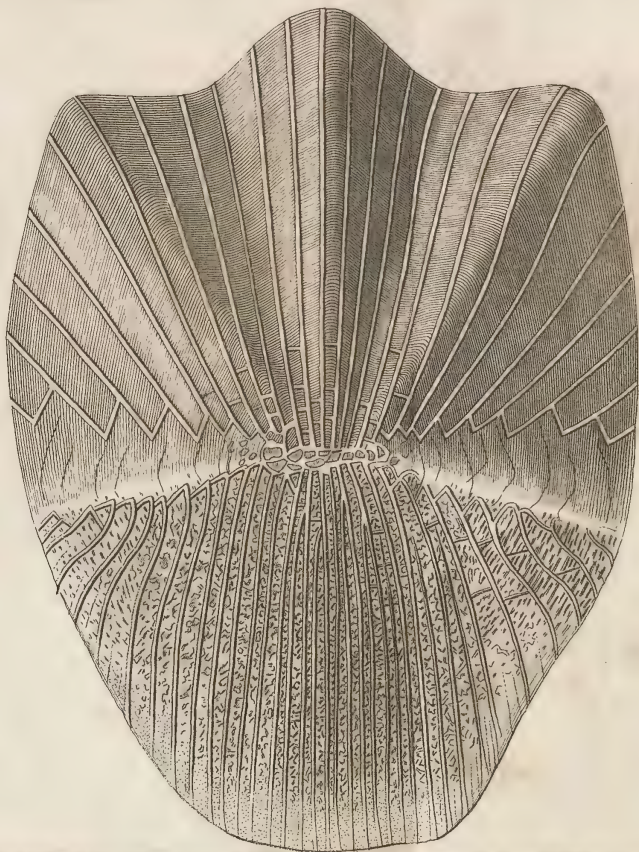


Fig. 8.



Fig. 9.

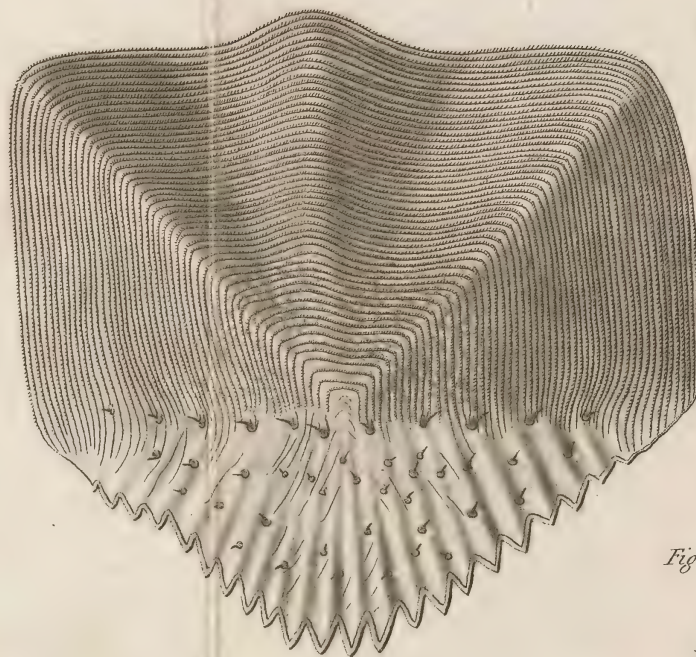


Fig. 10.





or skin, which in these answer the purpose of bones. The skin serves as a continent to the whole insect, covering the body, connecting the parts, and maintaining them in their proper places. This external covering is very strong in those insects, which, by the nature of their life, are exposed to strong friction, or violent compression; but is more tender and delicate in those which are not so exposed. The skin of insects, like that of larger animals, is porous; the pores in some species are very large. Many insects often change or cast off their skin; this exuvia forms an excellent object for the microscope.

Another distinguishing criterion of insects is the colour of their blood, which is never red; this, at first sight, seems liable to some objections, on account of the drop of red liquor which is often procured from small insects when squeezed or pressed to pieces. It does not appear, however, that this is the blood of the little animal; when it existed as a worm there was no such appearance, and when they exist as a fly it is only found in the eye, and not in the body, which would be the case if it circulated in the veins of the insects. It is probable there is a circulation of some fluid analagous to the blood in most insects: with the assistance of the microscope this circulation may be perceived in many; but the circulating liquor is not red.

To these discriminating characteristics we may also add the following particulars: 1. That the body of insects is divided by incisuræ, or transversal divisions, from whence they take their name.

Z

2. That

2. That they are furnished with antennæ, which are placed upon the fore part of the head; these are jointed, and moveable in various directions.

3. That no insect in it's perfect state, or after it has gone through all it's transformation, has less than six legs, though many have more. There are some moths, whose two fore feet are so small as scarcely to deserve that name. A proper attention to the nature and number of the feet of insects would tend to fix their real rank in that scale of animated nature, which is handed down to us in the sacred scriptures; a scale which, from the lively representations it holds forth, as well as their moral applications to the purposes of life, and the source from whence it is derived, shews that it is replete with the most important information.

4. That insects have neither the organs of smell nor hearing; at least they have not as yet been discovered, though it is reported that Fabricius has lately found and described the organs of hearing in the lobster.

5. That they do not respire air by the mouth, but that they inspire and exhale it, by means of organs which are placed on the body.

6. That they move the jaws from right to left, not up and down.

7. That they have neither eye-lid nor pupil.

To these we may also add, that the mechanism resulting from the LIFE of insects is not of so compound a nature as in animals of a larger size. They have less variety of organs, though some of the organs are more multiplied; and it is by the number and situation of these that their rank in the great scale of beings is to be determined.

These characters are often united in the same insect; there are, however, some species in which one or two of them are wanting.

Every microscopic observer, who wishes to avail himself of the discoveries of other writers, or to communicate intelligibly his own, will find it necessary to make himself master of the various classes, genera, &c. into which insects have been divided by LINNÆUS. All systems have their defects, and it is highly probable that this may be the case with that of the celebrated Linnæus: but the purpose of science is answered by using those discriminations which are generally adopted.

The following general idea of the Linnæan classes may serve as a foundation for this knowledge: a fuller account may be obtained by consulting the under-mentioned works.

Institutions of Entomology, a translation of Linnæus's *Ordines et Genera Insectorum*, or Systematic Arrangement of Insects, &c. by Thomas Pattison Yeats.

Fundamenta Entomologica, or an Introduction to the Knowledge of Insects, translated from Linnæus by W. Curtis, author of the *Flora Londinensis*, *Botanical Magazine*, &c.

The Genera Insectorum of Linnæus, exemplified by various Specimens of English Insects, drawn from Nature, by James Barbut.

Class the first. COLEOPTERA. The insects of this class have four wings; the upper ones, called the elytra, are crustaceous, formed of a hard bony substance, which, when shut, form a longitudinal future down the back, as in the scarabæus, melolontha, or cockchaffer, &c. &c.

2. HEMIPTERA. These have also four wings; but the elytra are different, being half crustaceous, half membranaceous: the wings do not form a longitudinal future, but extend the one over the other, as in the gryllus, grasshopper, &c.

3. LEPIDOPTERA. Those which have four membranaceous wings covered with fine scales, as the butterflies and moths.

4. NEUROPTERA. These have four membranaceous transparent wings, which are generally reticulated, as in the libellula, or dragon flies.

5. HYMENOPTERA. These, like the preceding class, have four membranaceous wings; but the abdomen is furnished with a sting, as in the bees, wasps, &c.

6. DIPTERA. These have only two wings, as common house flies, gnats, &c.

7. AP-

7. **APTERA.** These have no wings, as spiders, lice, acari, &c.

OF THE TRANSFORMATION OF INSECTS.

Insects are further distinguished from other animals by the wonderful changes that all, except those of the aptera class, pass through. Most animals retain, during their whole life, the same form which they receive at their birth; but insects go through wonderful exterior and interior changes, insomuch that the same individual, at it's birth and middle state, differs essentially from that under which it appears when arrived at a state of maturity; and this difference is not confined to marks, colour, or texture, but is extended to their form, proportion, motion, organs, and habits of life.

The ancient writers on natural history were not unacquainted with these transformations, but the ideas they entertained of them were very imperfect, and often erroneous. It was not till towards the latter end of the last century that any just conception of this subject was formed, and the mystery was then unveiled by those two great anatomists Malphigi and Swammerdam, who observed these insects under every appearance, and by dissecting them at the time just preceding their changes, were enabled to prove that the moth and butterfly grow and strengthen themselves, and that their members are formed and unfolded, under the figure of the insect we call a caterpillar; and they also shewed, that it is not difficult to exhibit in these all the parts of the future moth, as it's wings, legs, antennæ, &c. and consequently, that the changes which are apparently sudden to our eyes, are gradually

dually formed under the skin of the animal, and only appear sudden to us, because the insect then gets rid of a case which had before concealed his real members. These transformations clearly prove, that without repeated experience every thing in nature would appear a mystery : for who, on considering by the mere light of nature or reason a gnat or butterfly in their fly or perfect state, could have discovered the relation which in this state and form it bears to the several changes of state, and their corresponding forms, through which it has passed,* and which are so appearance as distinct as difference can make them.

The life of those insects which pass through these various changes, may be divided into four principal parts, each of which will be found truly worthy of all the attention of the microscopic observer.

The first change is from the EGG into the LARVA ; or, as it is more generally called, into the worm or caterpillar.

From the LARVA it passes into the PUPA, or chrysalis state.

From the PUPA into the imago or fly state.

Few subjects can be found that are more expressive of the extensive goodness of Divine Providence, than these transformations, in which we find the occasional and temporary parts and organs of

* All is phenomenon, and type on earth,
Replete with sacred and mysterious birth.

of these little animals suited and adapted with the most minute exactness to the immediate manner and convenience of their existence; which again are shifted and changed, upon the insects commencing a new scene and state of action.

In it's larva state the insect appears groveling, heavy, and voracious, in the form of a worm, with a long body, composed of successive rings; crawling along by the assistance of these, or small little hooks, which are placed on the side of the body. It's head is armed with strong jaws, it's eyes smooth, entirely deprived of sex, the blood circulating from the hind part towards the head. It breathes through small apertures, which are situated on each side of the body, or through one or more tubes placed in the hinder part thereof. While it is in the larva state, the insect is as it were masked, and it's true appearance concealed; for under this mask the more perfect form is hidden from the human eye.

In the pupa state the insect may be compared to a child in swaddling clothes; it's members are all folded together under the breast, and inclosed within one or more coverings, remaining there without motion. While in this state, no insect but those of the hemiptera class take any nourishment. This change is effected various ways; in some insects the skin of the larva opens, and leaves a passage, with all it's integuments; in others, the skin hardens and becomes a species of cone, which entirely conceals the insects; others form or spin cones for themselves, and in this state they remain till the parts have acquired sufficient firmness, and are ready to perform their several offices.

The

The insect then casts off the spoils of it's former state, and appears in it's imago or perfect form; for it has now attained the state of organical perfection, which answers to the rank it is to hold in the corporeal world. They are now furnished with wings, magnificently adorned; soar above and despise their former pursuits, wing the soft air, chuse their mates, and transmit their nature to a succeeding race. Their members, which in the preceding state were wrapped up, soft, and motionless, now display themselves, grow strong, and are put in exercise. The interior changes are as considerable as those of the exterior form, and that in proportion as the first state differs from the last; some organs acquire greater strength and firmness, others are rendered more delicate, some are suppressed, and some unfolded, which did not seem to exist in the former stages of it's life.

“ Who that beholds the summer's glitt'ning swarms,
Ten thousand thousand gaily gilded forms,
In volant dance of mix'd rotation play,
Bask in the beam, and beautify the day;
Who'd think these airy wantons so adorn,
Were late his vile antipathy and scorn;
Prone to the dust, or reptile thro' the mire,
And ever thence unlikely to aspire?
Or who, with transient view beholding, loaths
Those crawling sects, whom vilest semblance cloahs:
Who with corruption hold their kindred state,
As by contempt, or negligence of fate;
Could think that such, revers'd by wond'rous doom,
Sublimar pow'rs and brighter forms assume;

From

From death their future happier life derive,
 And, tho' apparently entomb'd, revive;
 Chang'd, thro' amazing transmigration, rise,
 And wing the regions of unwonted skies."*

OF THE LARVA STATE.

As the larvæ (caterpillars) of the moth and butterfly † form the most numerous family among the tribe of insects, and have been more particularly observed than any other kind, perhaps on account of the usefulness of one of their number, and are therefore best known, we shall first describe them, and their various changes from this state to their last and perfect form, and then proceed to those insects which differ most from the caterpillar in one or all of their various changes.

The greater part of those insects which come forth in spring or summer perish or disappear at the approach of winter; there are very few, the period of whose life exceeds that of a year; some survive the rigours of winter, being concealed and buried under ground; many are hid in the bark of trees, and others in the chinks of old walls; some, like

A a the

* Brooke's Universal Beauty.

† The butterflies are distinguished from the moth by the time of their flying abroad, and by their antennæ; the butterflies appear by day, their antennæ are generally terminated by a little knob; the moths fly mostly in the evening, and their antennæ are either setaceous or pectinated.

the caterpillar of the brown-tailed moth,* which was so uncommonly numerous and destructive near London, in the year 1782, at the approach of winter not only secure and strengthen the web, in which the society inhabit, and thus protect themselves from impertinent intruders, but each individual also spins a case for itself, where it rests in torpid security, notwithstanding the inclemency of the season, till the spring animates it afresh, and informs them that the all-bountiful Author of nature has provided food convenient for them. Many that are hatched in the autumn retire and live under the earth during the winter months, but in the spring come out, feed, and proceed onward to their several changes; while no small part pass the colder months in their chrysalis, or pupa state: but the greater number of the caterpillar race remain in the egg, being carefully deposited by the parent fly in those places where they will be hatched with the greatest safety and success; in this state the latent principle of life is preserved till the genial influences of the spring call it into action, and bring forth the young insect to share the banquet that nature has provided; then wherever we turn, or wherever we move, we find this insect in one shape or another.

“ When first breaks forth the bright enliv’ning ray;

* * * * *

————— The gay, the quick’ning insects rise,
And gilded squadrons strike our wond’ring eyes;
Music flies wanton from ten thousand wings,
And life and joy through ev’ry region rings.”—†

All

* Curtis’s short history of the brown-tailed moth.

† Brooke’s Universal Beauty.

All caterpillars are hatched from the egg, and when they first proceed from it are generally small and feeble, but grow in strength as they increase in size. The body of the caterpillar is divided into twelve rings; the head is connected with the first, and is hard and crustaceous. No caterpillar of the moth or butterfly has less than eight, or more than sixteen feet; those which have more than sixteen are not the larva of the moth or butterfly; the six first feet are crustaceous, pointed, and fixed to the three first rings of the body; these feet are the covering to the six future feet of the moth; the other six feet are soft and flexible, or membranaceous; they vary both in figure and number, and are proper only to the larva state: with respect to their external figure, they are either smooth or hairy, soft to the touch, or hard like shagreen, beautifully adorned with a great variety of the most lively tints; on each side of the body nine little oval holes are placed, which are generally considered as the organs of respiration. There are on each side of the head of the caterpillar five or six little black spots, which are supposed to be its eyes. These creatures vary in size, from half an inch long to four and five inches.

The caterpillar, whose life is one continued succession of changes, often moults its skin before it attains its full growth. These changes are the more singular, because when the caterpillar moults, it is not simply the skin that is changed; for we find in the exuvia the skull, the jaws, and all the exterior parts, both scaly and membranaceous, which compose its upper and under lip, its antennæ, palpi, and even those crustaceous pieces within the head, which serve as a fixed basis to a number of muscles; we further find in the exuvia, the spiracula, the claws,

and sheaths of the anterior limbs, and in general all that is visible of the caterpillar.

The new organs were under the old ones as in a sheath, so that the caterpillar effects the changes by withdrawing itself from the old skin, when it finds itself lodged in too narrow a compass. But to effect this change, to push off the old covering, and bring forwards the new, is a work of labour and time. Those caterpillars who live in society, and have a kind of nest or habitation, retire there to change their skin, fixing the hooks of the feet, during the operation, firmly in the web of their nest. Some of the solitary species spin at this time a slender web, to which they affix themselves. A day or two before the critical moment approaches, the insect ceases to eat, and loses its usual activity; in proportion as the time of change approaches, the colour of the caterpillar becomes more feeble, the skin hardens and withers, and is soon incapable of receiving those juices by which it was heretofore nourished and supported. The insect may now be seen, at distant intervals, to elevate its back, and stretch itself to its utmost extent; sometimes to lift up the head, move it a little from side to side, and then let it fall again; near the change, the second and third rings are seen to swell considerably; by these internal efforts the old parts are stretched and distended as much as possible, an operation which is attended with much difficulty, as the new parts are all weak and tender. However, by repeated exertions, all the vessels which conveyed the nourishment to the exterior skin are disengaged, and cease to act, and a slit is made on the back, generally beginning at the second or third ring; the new skin may now be just perceived, being distinguished by the freshness and brightness of its colour; the caterpillar then presses the

the body like a wedge into this slit, by which means it is soon opened from the first down to the fourth ring; this renders it large enough for the insect to pass through, which it soon effects in a very curious manner. The caterpillar generally fasts a whole day after each moulting, for it is necessary that the parts should acquire a certain degree of consistency, before it can live and act in its usual manner; many also perish under the operation.

The insect always appears much larger after it has quitted the exuvia; the body had grown under the old skin, till it was become too large for it: now as the growth was gradual, and the parts soft, the skin pressed them together, so that they lay in a small space; but as soon as the skin is cast off, they are as it were liberated from their bonds, and distend themselves considerably. Some caterpillars, in changing their skin, from smooth become covered with fine hair; while others, that were covered with this fine hair, have the last skin smooth.*

OF THE PUPA.

Before we describe the change of the larva into the pupa state, it will be necessary to give the reader an account of those names by which naturalists distinguish the different appearances of insects in the pupa state.

It is called *COARCTATA*, when it is straitened or confined to a case of a globular form, which has no resemblance to the insect it contains.

It

* Valmont de Bomare Dictionnaire Universel d'Histoire Naturelle, vol. ii. 2d edit. 12mo. p. 394.

It is called *OBTECTA*, disguised or shrowded, when the insect is enveloped in a crustaceous covering, consisting of two parts, one of which surrounds the head and thorax, the other the abdomen.

It is termed *INCOMPLETEA*, when the pupa has perceptible wings and feet, but cannot move them.

SEMICOMPLETA; these can walk or run, but have only the rudiments of wings. The difference between the pupa and the larva of this class is very inconsiderable, as they eat, walk, and act, just as they did in their primitive state; the only remarkable difference is a kind of case, which contains the wings that are to be developed in their fly state.

COMPLETA; those designed by this name take their perfect form at their birth, and do not pass, like other insects, through a variety of states, though they often change their skin.

It is a general rule, that all winged insects pass through the larva and pupa state before they assume their perfect form: there are also insects which have no wings, and yet undergo similar transformation, as the bed bug, the flea, &c. Other insects, which have no wings, and which always remain without them, never pass through the pupa state, but are subject to considerable changes, as well with respect to the number as the figure of their parts; thus mites have four pair of feet, and two smaller ones at the fore part of the body, near the head; yet some of these are born with only three pair of feet, the fourth is not perceived till some time after their birth.* The figure of the monocus quadri-

* De Geer *Memoires pour servir à l'Histoire des Insectes*, tom. 1. p. 154.

quadricornis of Linnæus (*Fauna Suecica*, edit. Stockholm, 1761, No. 2049), changes considerably after it's birth.* The *julus* is an insect with a great number of feet, some species having an hundred pair and upwards. M. De Geer has given a description of one with more than two hundred pair,† and yet these at their birth have only three pair, the rest are not perceived till some time after.

We shall now return to the caterpillar, and take notice of the care and provision it makes to pass from the larva state into that of the pupa, or chrysalis; which is, in general, a state of imperfection, inactivity, and weakness, through which the insect, when it has obtained a proper size, must pass; and in which it remains often for months, sometimes for a whole year, exposed, without any means of escaping, to every event; and in which it receives the necessary preparations for it's perfect state, and is enabled once more to appear upon the transitory scene of time. During it's passage from one state to the other, as well as when it is in the pupa form, the microscopical observer will find many opportunities of exercising his instrument.

The transitions of the caterpillar from one state to another, are to it a subject of the most interesting nature; for in passing through them, it often runs the risk of losing it's life, and life is the greatest boon the Creator can bestow; it is ever accompanied with a degree of delight proportioned to the state in which the creature exists, and the use it makes of the gift it has received. If the caterpillar could therefore foresee the efforts and exertions it must

* De Geer *Memoires pour servir à l'Histoire des Insectes*, tom. 1, p. 155.

† *Memoires des Sçavans etrangers*, tom. 3, p. 61.

must make to put off it's present form, and the state of weakness and impotence under which it must exist while in the pupa state, it would undoubtedly chuse the most convenient place, the most advantageous situation, for the performance of this arduous operation; one where it would be the least exposed to danger, when it had neither strength to resist, nor swiftness to avoid the attack of an enemy.

All these necessary instructions the caterpillar receives from the influence of an all-regulating Providence, which conveys the proper information to it by it's own sensations: hence, when the critical period approaches, it proceeds as if it knew what would be the result of it's operations. Different species prepare themselves for this state in different ways, suited to their nature and the length of time they are to remain in this state.

When the caterpillar has attained to it's full growth, and the parts of the future butterfly are sufficiently formed beneath it's skin, it prepares for it's change into the pupa state; it seeks for a proper place in which to perform the important business: the different methods employed by these little animals to secure this state of rest, may be reduced to four: 1. Some spin webs, or cones, in which they inclose themselves; 2. Others conceal themselves in little cells, which they form under ground; 3. Some suspend themselves by their posterior extremity; 4. While others are suspended by a girdle that goes round their body. We shall describe the variety in these, as well as the industry used in constructing them, after we have gone through the manner in which the caterpillar prepares itself for and passes through the pupa state.

Preparatory to the change, it ceases to take any food, empties itself of all the excrementitious matter that is contained in the intestines, voiding at the same time the membrane which served as a lining to these and the stomach. It generally perseveres in a state of rest and inactivity for several days, which affords the external and internal organs that are under the skin an opportunity of gradually unfolding themselves. In proportion as the change into the pupa form approaches, the body is observed often to extend and contract itself; the hinder part is that which is first disengaged from the caterpillar skin; when this part of the body is free, the animal contracts and draws it up towards the head; it then liberates itself in the same manner from the two succeeding rings, consequently the insect is now lodged in the fore part of its caterpillar covering; the half which is abandoned remains flaccid and empty, while the fore part is swollen and distended. The animal, by strong efforts, still forcing itself against the fore part of the skin, bursts the skull into three pieces, and forms a longitudinal opening in the three first rings of the body; through this it proceeds, drawing one part after the other, by alternately lengthening and shortening, swelling and contracting the body and different rings; or else, by pushing back the exuvia, gets rid of its odious reptile form.

The caterpillar, thus stripped from its skin, is what we call the pupa, chrysalis, and aurelia, in which the parts of the future moth are inclosed in a crustaceous covering, but are so soft, that the slightest touch will discompose them. The exterior part of the chrysalis is at first exceedingly tender, soft, and partly transparent, being covered with a viscous fluid; this soon dries up, thickens, and forms a new covering for the animal, capable of

resisting external injuries; a case, which is at the same time the sepulchre of the caterpillar, and the cradle of the moth; where, as under a veil, this wonderful transformation is carried on.

The pupa has been called a chrysalis, or creature made of gold, from the resplendent yellow colour with which some kinds are adorned. M. de Reaumur has shewn us whence they derive this rich colour; that it proceeds from two skins, the upper one a beautiful brown, which lays upon or covers a highly-polished and smooth white skin: the light reflected from the last, in passing through, gives it the golden yellow, in the same manner as this colour is often given to leather; so that the whole appears gilded, although no gold enters into the tincture. The chrysalis of the common white butterfly furnishes a most beautiful object for the lucernal opake microscope.

Those who are desirous to discover distinctly the various members of the moth in the pupa, should examine it before the fore-mentioned fluid is dried up, when it will be found to be only the moth, with the members glued together; these, by degrees, acquire sufficient force to break their covering, and disengage themselves from the bands which confine them.

To examine the moth concealed under the skin of a caterpillar, one of them should be taken at the last change; when the skin begins to open, it should be drowned in spirits of wine, or some strong liquor, and be left therein for some days, that it may take more consistency and harden itself; the skin of the caterpillar may then be easily removed: the chrysalis, or feeble moth, will be first discovered, after which the tender moth may be traced:

traced out, and it's wings, legs, antennæ, &c. may be opened and displayed by an accurate observer.

The parts of the moth, or butterfly, are not disposed exactly in the same manner in the body of the caterpillar, as when left naked in the chrysalis. The wings are longer and narrower, being wound up into the form of a cord, and the antennæ are rolled up on the head; the tongue is also twisted up and laid upon the head, but in a very different manner from what it is in the perfect animal, and different from that which it lies in within the chrysalis; so that it is by a progressive and gradual change, that the interior parts are prepared for the moth and pupa state. The eggs, hereafter to be deposited by the moth, are also to be found not only in the chrysalis, but in the caterpillar itself, arranged in their natural and regular order.

The time which the moth, or butterfly, remains in the pupa state is not always the same, varying in different species, and depending also upon the warmth of the weather, and other adventitious circumstances; some remain in that situation for a few weeks; others do not attain their perfect form for eight, nine, or eleven months: this often depends on the season in which they assume the pupa form, or rather on the time of their birth. Some irregularities are also occasioned by the different temperature of the air, by which they are retarded or accelerated, so as to be brought forward in the season best suited to their nature and the ends of their existence. I have heard of an instance, where the pupa produced from caterpillars of the same eggs, nourished in the same manner, and which all spun up within a few days of each other in the autumn, came into the fly state at three different

and distant periods, viz. one-third of them the spring following their change, one-third more the succeeding spring, and the remainder the spring after; making three years from their first hatching; a further and manifest proof of the beauty and wisdom of the laws of Divine order, which are continually operating for the best interests of all created beings. As the transformation of insects is retarded by cold, and accelerated by heat, the ordinary period of these changes may sometimes be altered, by placing them in different degrees of heat or cold; by these they may be awakened sooner to a new state of existence, or kept in one of profound sleep.*

There are some caterpillars who remain in their case eight or nine months, before they become complete chrysalides; so that their duration in the pupa state is much shorter than it naturally appears to be.

As soon as the moth acquires sufficient strength to break the bonds which surround it, and of which it is informed by its internal sensations, it makes a powerful effort to escape from its prison, and view the world with new-formed eyes. The moth frees itself from the pupa with much greater ease than the pupa from the caterpillar; for the case of the pupa becomes so dry, when the moth is near the time of throwing off its covering, that it will break to pieces if it be only gently pressed between the fingers; and very few of the parts will be found, on examination, to adhere to the body. Hence when the insect has acquired a proper degree of solidity, it does not require any great exertion to split the membrane which covers it. A small degree of motion,

* Reaumur Memoires sur les Insectes, tom. 2, mem. 1.

motion, or a little inflation of the body, is sufficient for this purpose; these motions reiterated a few times, enlarge the hole, and afford the moth room to escape from it's confinement. The opening through which they pass is always at the same part of the skin, a little above the trunk, between the wings and a small piece which covers the head; the different fissures are generally made in the same direction. If the outer case is opened, it is easy to discover the efforts the insect makes to emancipate itself from it's shell; when the operation begins, there seems to be a violent agitation in the humours contained in the little animal; the fluids seem to be driven with rapidity through all the vessels, and it is seen to agitate it's legs, &c. as it were struggling to get free; these efforts, as we have already said, soon break it's brittle skin.

The loosening the exterior bands of the pupa is not the only difficulty many moths have to encounter with; it has often also to pierce the cone, or case, in which it has been inclosed, and that at a time when it's members are very feeble, when it is no longer furnished with strong jaws to pierce and cut it's way through; but, by the regular laws of Divine order, means are furnished to every creature of attaining the end for which it was produced: thus, in the present case, some of these insects are provided with a liquor with which they soften and weaken the end of the cone; some leave one end feeble, and close it only with a few threads, so that a slight effort of the head enables the moth to burst the prison doors, and immerge into day.

When the moth first sees the day, it is humid and moist; but this humidity soon evaporates, the interior parts dry and harden as well as the exterior; the wings, which are crumpled, or thick
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and small, extend themselves, are strengthened and hardened insensibly, and the fibres which were at first flexible become hard and stiff; even so stiff, that Malphigi considered them as bones: in proportion as these fibres harden, the fluid which circulates within them, and extends the wings, loses it's force; so that if any extraneous circumstance prevents the motion of this fluid, at the first instant of the moth's escape from it's former state, the wing will then become ill-shaped; often expanding with such rapidity, that the naked eye cannot trace it's unfolding. The wing, which was scarce half the length of the body, acquires in a few minutes it's full size, so as to be nearly five times as large as they were before: nor is it the wings only, which are thus increased; all their spots and colours, heretofore so minute as to be scarce discernible, are proportionally extended, so that what before appeared as only so many unmeaning and confused points, become distinct and beautiful ornaments; and those that are furnished with a tongue, or trunk, curl and coil it up.

When the wings are unfolded, the tongue rolled up, the moth sufficiently dried, and the different members strengthened, it takes it's flight. Most of them, soon after they have attained their perfect state, void an excrementitious substance, which M. de Reaumur thinks is the last time of their doing it; that they reject very little, if any, during the rest of their lives.

If the moth is opened down the belly, and the fatty parts which fill it are removed, the gross artery, which has been called the heart, will be visible, and the contractions and dilations, by which it pushes forwards the liquor it contains, may be easily observed. One of the most remarkable circumstances is, that the

circulation of this fluid in the moth is directly contrary to that which took place in the caterpillar; in this the liquor moved from the tail to the head, whereas in the moth it moves from the head to the tail; so that the fluid which answers the purposes of the blood in the moth, goes from the superior towards the inferior parts; but in the voracious sensual caterpillar the order is inverted, it proceeds from the inferior towards the superior parts.

The food of the caterpillar is gross and solid, and even this it is obliged to earn with much labour and danger; but when freed as it were from the jaws of death, and arrived at it's perfect form, the purest nectar is it's portion, and the air it's element. It was supplied with coarse food, in the first state, by the painful operation of it's teeth, which was afterwards digested by a violent trituration of the stomach. The intestines are now formed in a more delicate manner, and suited to a more pure and elegant aliment, which nature has prepared for it's use, from the most fragrant and beautiful flowers. Many internal parts of the caterpillar disappear in the chrysalis, and many that could not be perceived before are now rendered visible: the interior changes are not less surprizing than those of the exterior form, and are, properly speaking, creative of them; for it is from these the exterior form originates, and to these it always corresponds. In a word, the creature that heretofore crept upon the earth, now flies freely through the air; and far from creating our aversion by it's frightful prickles and foul appearance, it attracts our notice by the most elegant shape and cloathing.*

Yon.

* Swammerdam's Book of Nature, p. 10.

Yon maggot, vilest offspring of the earth,
 Answers the genial baseness of his birth :
 Lo ! where he rolls and battens with delight
 In filth, to smell offensive, foul to fight !
 Well pleas'd he drinks the stench, the dirt devours,
 And prides him in the puddle of his pow'rs ;
 Careless, unconscious of the beauteous guest,
 Th' internal speck committed to his breast ;
 Yet in his breast th' internal speck grows warm,
 And quickens into motion, life, and form :
 Far other form than that it's fosterer bore,
 High o'er it's parent worm ordain'd to soar.
 The son still growing as the fire decays,
 In radiant plume his infant form arrays ;
 Matures as in a soft and silent womb,
 Then op'ning, peeps from his paternal tomb ;
 Now struggling, breaks at once into the day,
 Tries his young limbs, and bids his wings display ; -
 Expands his lineaments, erects his face,
 Rises sublime o'er all the reptile race ;
 From dew-dropt blossoms sips the nectar'd stream,
 And basks within the glory of the beam. *

The industry of the caterpillar, in securing itself for it's change into the chrysalis, must not be passed by ; not only because they naturally lead the reader to consider and admire that Divine agency by which they are informed, but because the different modes they make use of cannot be properly investigated, without the

* Brooke's Redemption.

the assistance of glasses, and are consequently a proper subject for the microscope; we shall select from a great variety, a few instances, to animate the reader in these researches.

Some caterpillars, towards the time of their change, suspend themselves from the branch of a tree, with the head downwards; in this position they assume the pupa form, and from thence immerge a butterfly or moth. In order to suspend itself in this position, the insect covers with threads that part of the branch from which it means to suspend itself; it places these in different directions, and then covers them with other threads, laying on several successive thicknesses, each new layer being smaller in size than that which preceded it; forming, when finished, a little cone or hillock of silk, as will be found when examined by the microscope. The caterpillar hooks itself by the hinder feet to this hillock; and when it has found, by several trials, that it is strongly fixed thereto, throws itself forward, letting the body fall with the head downwards. Soon after it is thus suspended, it bends the fore part of the body, keeping this bent posture for some time; then straitening the body, again in a little time bending it, and so on, repeating this operation till it has formed a slit in the skin upon the back; part of the pupa soon forces itself through this, and extends the slit as far as the last crustaceous feet; the pupa then forces upwards the skin, as we would push down a stocking, by means of it's little hooks and the motion of the body, till it has slipped it off to that part from which the caterpillar had suspended itself. But the pupa has still to disengage itself from this small packet, to which the exuvia is now reduced: here the observer will find himself interested for the little animal, anxious to learn how the pupa will quit this

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skin,

skin, and how it will be enabled to fix itself to the hillock, as it has neither arms nor legs. A little attention soon explains the operation, and extricates the observer from his embarrassment. It seizes the exuvia by the rings of the body, and thus holds itself as it were by a pair of pincers; then, by bending the tail, it frees itself from the old skin, and by the same method soon suspends itself to the filken mount; it lengthens out the hinder part of the body, and clasps, by means of its rings, the various foldings of the exuvia one after another; thus creeping backward on the spoils, till it can reach the hillock with the tail; which, when examined by the microscope, will be found to be furnished with hooks to fix itself by.

It is surprizing to see with what exactness and ease these insects perform an operation so delicate and dangerous, which is only executed once in their life; and nought else can account for it, but the consideration that he, who designed that the caterpillar should pass through these changes, had provided means for that end, regularly connecting the greater steps by intermediate ones, the desire of extending their species, forming and acting upon the organization, till the purposes of their life are completed.

Different kinds of these insects require variety in the mode of suspension; some fix themselves in an horizontal position, by a girdle which they tie round their body; this girdle appears to the naked eye as a single thread; when examined with the microscope, it will be found to be an assemblage of fine threads, lying close to each other, so fixed as to support the caterpillar, and yet leave it in full freedom to effect the changes. Like the preceding kind, it fixes the girdle to the branch of a tree; in this situation

it remains for some time motionless, and then begins to bend, move, and agitate it's body in a very singular manner, till it has opened the exterior covering, which it pushes off and removes much in the same manner as we have described in the preceding article, and yet with such dexterity, that the pupa remains suspended by the same girdle.

The industry of those that spin cones, or cases, in which they inclose themselves, in order to prepare for their transformation in security, is more generally known, as it is from one species of these that we derive so many benefits, namely, from the silk-worm. All caterpillars undergo similar changes with it, and many in the butterfly state greatly exceed it in beauty: but the golden tissue, in which the silk-worm wraps itself, far surpasses the silky threads of all the other kinds; they may indeed come forth with a variety of colours, and wings bedecked with gold and scarlet, yet they are but the beings of a summer's day; both their life and beauty quickly vanish, and leave no remembrance after them; but the silk-worm leaves behind it such beneficial monuments, as at once record the wisdom of their Creator, and his bounty to man.*

The substance of which the silk is formed, is a fine yellow transparent gum, contained in two reservoirs that wind about the intestines, and which, when they are unfolded, are about ten inches long; they terminate in two exceeding small orifices near the mouth, through which the silk is drawn, or spun, to the degree of fineness which it's occasions may require. This apparatus has been compared to the instrument used by the wire-drawers,

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and

* Pullen on the Culture of Silk.

and by which gold and silver is drawn to any degree of minuteness. Every thread proceeds from these two reservoirs, but are united afterwards; so that if it is examined by the microscope, it will be found to consist of two cylinders, or threads, glued together, with a groove in the middle; a separation may sometimes be perceived.

When the silk-worm has found a convenient situation, it sets to work, first spinning some loose thread, which serves to support the future superstructure; upon these it forms an oval of a loose texture, consisting of what is called the floss silk; within this it forms a firm and more consistent ball of silk, remaining during the whole business within the circumference of the spheroid that it is forming, resting on it's hinder parts, and with it's mouth and fore legs directing and fastening the threads. These threads are not directed in a regular circular form, but are spun in different spots, in an infinite number of zig-zag lines: so that when it is wound off, it proceeds in a very irregular manner, sometimes from one side of the cone, then from the other. This thread, when measured, has been found to be about three hundred yards long, and so fine, that eight or ten are generally rolled off into one by the manufacturers. The silk-worm usually employs about three days in finishing this cone; the inside is generally smeared with a kind of gum, that is designed to keep out the rain; in this cone it assumes the pupa form, and remains therein from fifteen to thirty days, according to the warmth of the climate. When the moth is formed, it moistens the end of this cone, and by frequent motions of the head loosens the texture of the silk, so as to form a hole without breaking it.

When

When the silk-worm has attained it's perfect growth, the reservoirs of silk are full, and it is pressed by it's sensations to get rid of this incumbrance, and accordingly spins a cone, the altitude and size of which are proportioned to it's wants : by traversing backwards and forwards, it is relieved, and thus attains, by an innate desire, the end for which it was formed.

The size of the cone is not always proportioned to the size of the caterpillar; some that are small construct larger cones than other caterpillars which are greater in size.

There is a caterpillar which forms it's silken cone in the shape of a boat turned bottom upwards, whence it is called by M. de Reaumur the "coque en bateau;" the construction is complicated, and seems to require more art than is usually attributed to this insect. It consists of two principal parts, shaped like shells, which are put together with considerable skill and propriety; each shell, or side, is framed by itself, and formed of an innumerable quantity of minute silk rings; in the fore part there is a projection, in which a small crevice may be perceived, which serves, when opened, for the escape of the moth; the sides are connected with so much art, that they open and shut as if framed with springs; so that the cone, from which the butterfly has escaped, appears as close as that which is still inhabited.

Those which are not furnished with a silky cone, supply their want with various materials, which they are sufficiently skilful to form into a proper habitation, to secure them while preparing for the perfect state; some construct their's with leaves and branches, tying them fast together, and then strengthening the connection;
others

others connect these leaves with great regularity ; many strip themselves of their hairs, and form a mixture of hair and silk ; others construct a cone of sand, or earth, cementing the particles with a kind of glue ; some gnaw the wood into a kind of saw-dust, and glue it together ; with an innumerable variety of modes suited to their present and future state.

OF THE BEETLE.

To make the reader more fully acquainted with a subject which affords such abundant matter for the exercise of his microscope, I shall proceed to describe, in as concise a manner as I am able, the changes of a few insects of different classes, beginning with the beetle.

The beetle is of the first (or coleopterous) class, having four wings. The two upper ones are crustaceous, and form a case to the lower ones ; when they are shut, there is a longitudinal future down the back : this formation of the wings is necessary, as the beetle often lives under the surface of the earth, in holes which they dig by their own industry and strength. These cases save their real wings from the damage which they might otherwise sustain, by rubbing or crushing against the sides of their abode ; they serve also to keep the wings clean, and produce a buzzing noise when the animal rises in the air. The strength of the beetle is astonishing ; it has been estimated that, bulk for bulk, their muscles are a thousand times stronger than those of a man.

The beetle is only an insect disengaged from the pupa form ; the pupa is a transformation in like manner from the worm, or larva,

larva, and this proceeds from the egg; so that here, as in the foregoing instances, one insect is exhibited in four different states of life, after passing through three of which, and the various miseries attendant on them, it is advanced to a more perfect state. When a larva, it trains a miserable existence under the earth: in the pupa form it is deprived of motion, and as it were dead. But the beetle itself lives at pleasure above and under ground, and also in the air, enjoying a higher degree of life, which it has attained by slow progression, and passing through difficulties, affliction, and death.

If we judge of the rank which the beetle holds in the scale of animation, from the places where they are generally found, from the food which nourishes them, from the disgusting and odious forms of many, from their antipathy to light, and their delight in darkness, we shall not form great ideas of the dignity of their situation. But as all things are rendered subservient to the laws of Divine order, it is sufficient for us to contemplate the wonders that are displayed in this and every other organ of life, for the reception of which, from the FOUNTAIN AND SOURCE OF ALL LIFE, each individual is adapted, and that in a manner corresponding to the state of existence it is to enjoy, and the energies it is called forth to represent; indeed the manner of its existence entirely depends on the degree of life which it is enabled to receive, and the state in which that degree is communicated in its descent through different orders of being.

“ One is the flood which universal flows;
And hence the reptile, hence the seraph glows.”

BROOKE.

The

The egg of the rhinoceros * beetle is of an oblong round figure, of a white colour; the shell thin, tender, and flexible; the teeth of the worm that is within the shell come to perfection before the other parts; so that as soon as it is hatched, it is capable of devouring, and nourishing itself with the wood among which it is placed. The larva, or worm, is curiously folded in the egg, the tail resting between the teeth, which are disposed on each side the belly; the worm, in proper time, breaks the shell, in the same manner as a chicken, and crawls from thence to the next suitable substance.

The worm, when it is hatched, is very white, has six legs, a wrinkled naked body, but the other parts all covered with hair: the head is then also bigger than the whole body, a circumstance which may be observed in larger animals, and which is founded on wise reasons.† If the egg is observed from time to time while the insect is within it, the beating of the heart may be perceived.

The eggs of the earth-worm, the snail, and the beetle, will afford many subjects for the microscope, and will be found to deserve a very attentive examination. Swammerdam was accustomed to hatch them in a dish, covered with white paper, which he always kept in a moist state. To preserve these and such like eggs, they must be pierced with a fine needle; the contained liquors must be pressed out, after which they should be blown up by means of a small glass tube, and then filled with a little rosin dissolved in oil of spike.

The

* *Scarabæus Aëdon*, Lin. Syst. Nat. p. 541-3.

† Swammerdam's Book of Nature, pt. 1, p. 33.

The worm of the rhinoceros beetle, like other insects in the larva state, changes it's skin; in order to effect which, it discharges all it's excrement, and forms a convenient hole in the earth, in which it may perform the wonderful operation; for it does not, like the serpent, cast off merely an external covering, but the throat, a part of the stomach, and the inward surface of the great gut, change at the same time their skin: as if it were to increase the wonder, and to call forth our attention to these representative changes, some hundreds of pulmonary pipes cast also each it's delicate skin, a transparent membrane is taken from the eyes, and the skull remains fixed to the exuvia.

After the operation, the head and teeth are white and tender, though at other times as hard as a bone; so that the larva, when provoked, will attempt to gnaw iron. For an accurate anatomical description of this worm, I must refer the reader to M. Swammerdam; he will find it, like the rest of this author's works, well worthy of his attentive perusal. To dissect it, he first killed it in spirits of wine, or suffocated it in rain water rather more than lukewarm, not taking it out from thence for some hours. This preparation prevents an improper contraction of the muscular fibres.

When the time approaches for the worm to take upon it the pupa form, it generally penetrates deeper into the ground,* or those places where it inhabits, to find a situation that it can more easily suit to it's subsequent process. Having found a proper

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place,

* The larva of those beetles which live under ground are in general heavy, idle, and voracious; on the contrary, the larva which inhabit the waters are exceedingly active.

place, they form with their hinder feet a polished cavity, in this they lie for some time immoveable; after which, by voiding excrementitious substances, and by the evaporation of humidity, it becomes thinner and shorter; the skin more furrowed and wrinkled, so that it soon appears as if it was starved by degrees. If it be dissected about this period, the head, the belly, and the thorax, may be clearly distinguished. While some external and internal parts are changing by a slow accretion, others are gently distended by the force of the blood and impelled humours. The body contracting itself, while the blood is propelled towards the fore-parts, forces the skull open in three parts, and the skin in the middle of the back is separated, by means of an undulating motion of the incisions of the back; at the same time the eyes, the horns, the lips, &c. cast their exuvia. During this operation, a thin watery humour is diffused between the old and new skin, which renders the separation easier. The process going on gradually, the worm is at last disengaged from its skin, and the limbs and parts are, by a continual unfolding, transformed into the pupa state; after which, it twists and compresses the exuvia by the fundament, and throws it towards the hinder part under the belly. The pupa is at this time very delicate, tender, and flexible; and affords a most astonishing appearance to an attentive observer. Swammerdam thinks it is scarce to be equalled among the wonders which are displayed in the insect part of the creation; in it the future parts of the beetle are finely exhibited, so disposed and formed, as soon to be able to serve the creature in a more perfect state of life, and to put on a more elegant form.

The

The pupa* of this insect weighs, a little after it's change, much heavier than it does in it's beetle state; this is also the case with the pupa of the bee and hornet. The latter has been found to weigh ten times as much as the hornet itself; this is probably occasioned by a superabundant degree of moisture, by which these insects are kept in a state of inactivity (a kind of preternatural dropsy) till it is in some measure dissipated; in proportion as this moisture is evaporated, the skin hardens and dries; some days are required to sweat off this superfluous moisture. If the skin is taken off at this time, many curious circumstances may be noted; but what claims our attention most is, that the horn, which is so hard in the male beetle when in a state of maturity, that it will bear to be sharpened against a grindstone,† in the pupa state is quite soft, and more like a fluid than a solid substance.

How long the scene of mutation continues is not known; some remain during the whole winter; more particularly those who quit the larva state in autumn, when a sudden cold checks their further operations, and consequently they remain without any food for several months. Some species of the beetle tribe go through all the stages of their existence in a season, while others employ near four years in the process, and live as winged insects a year.

When the proper time for the final change arrives, all the muscular parts grow strong, and are thus more able to shake off

D d 2

their

* Swammerdam's Book of Nature, p. 144.

† Mouffet, p. 152.

their last integuments, which is performed exactly in the same manner as in the passage of the insect from the larva to the pupa state, so that in this last skin, which is extremely delicate, the traces of the pulmonary tubes, that have been pulled off and turned out, again become visible.

All parts of the insect, and more particularly the wings and their cases, are at this time swelled and extended, by the air and fluids which are driven into them through the arteries and pulmonary tubes; the wings are at this period soft as wet paper, and the blood issues from them on the least wound; but when they have acquired their proper consistency, which in the elytra is very considerable, they will not give the least sign of any fluid within them, though cut or torn almost asunder.

The pupa being disengaged from its skin, assumes a different form, in which it is dignified with the name of a beetle, with a difference of sex, being either male or female.

The insect now begins to enjoy a life far preferable to its former state of existence; from living in dirt and filth, under briars and thorns, it now raises itself towards the skies, and sustains itself with the oozing liquors of flowers.

OF THE MUSCA CHAMELEON.

We proceed to illustrate the nature of the different transformations in insects, by giving an account of the musca chameleon: in the worm or larva condition it lives in the water, breathes by the tail, and carries its legs within a little snout near its mouth.

When

When it is arrived at the time for it's pupa state, it goes through the change without casting off the skin of the larva. Lastly, in the imago, or fly state, it would infallibly perish in the water: the element, which had hitherto supplied it with life and motion, would now be it's immediate destruction.

This insect is characterized by Linnæus as *musca chamæleon*. Habitat larva in aquis dulcibus; musca supra aquam obambulare solet. In a former edition of the Fauna Suecica he called it *oestrus aquæ*; but on a more minute examination, he found it was a *musca*; besides, the larvæ of all known oestri are nourished in the bodies of animals.

The larva of this insect, when viewed by the naked eye, appears to consist of twelve annular divisions, see Plate XI. Fig. 1; by these it is separated into a head, thorax, and abdomen; but as the stomach and intestines lie equally in the thorax and abdomen, it is not easy to distinguish their limits until the insect approaches the pupa state.

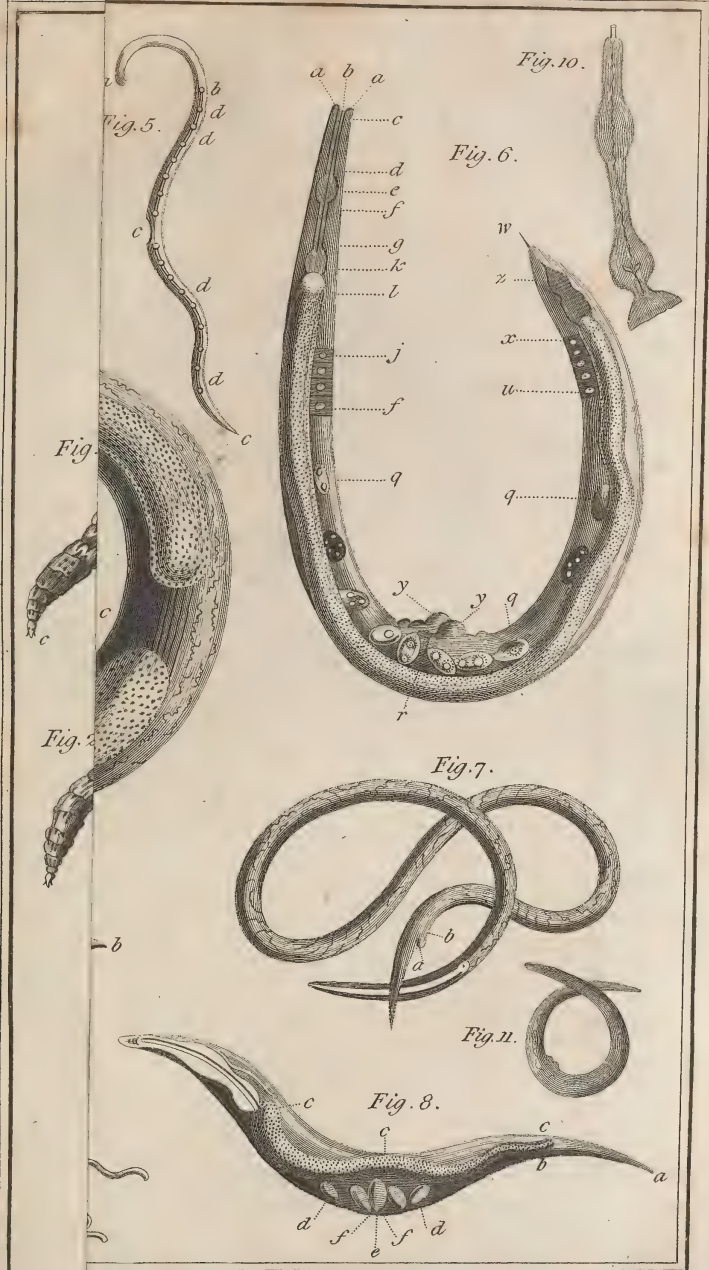
The parts most worthy of notice, when this insect is viewed by the naked eye, are the tail and snout. The tail is furnished with an elegant crown or circle of hair b, disposed quite round it in an annular form; by means of this the tail is supported on the surface of the water while the worm or larva is moving therein, the body in the mean while hanging towards the bottom; it will sometimes remain in this situation for a considerable time, without the least sensible motion. When it has a mind to sink to the bottom by means of it's tail, it generally bends the hairs of that part towards each other in the middle, but much closer towards the
6 extremity;

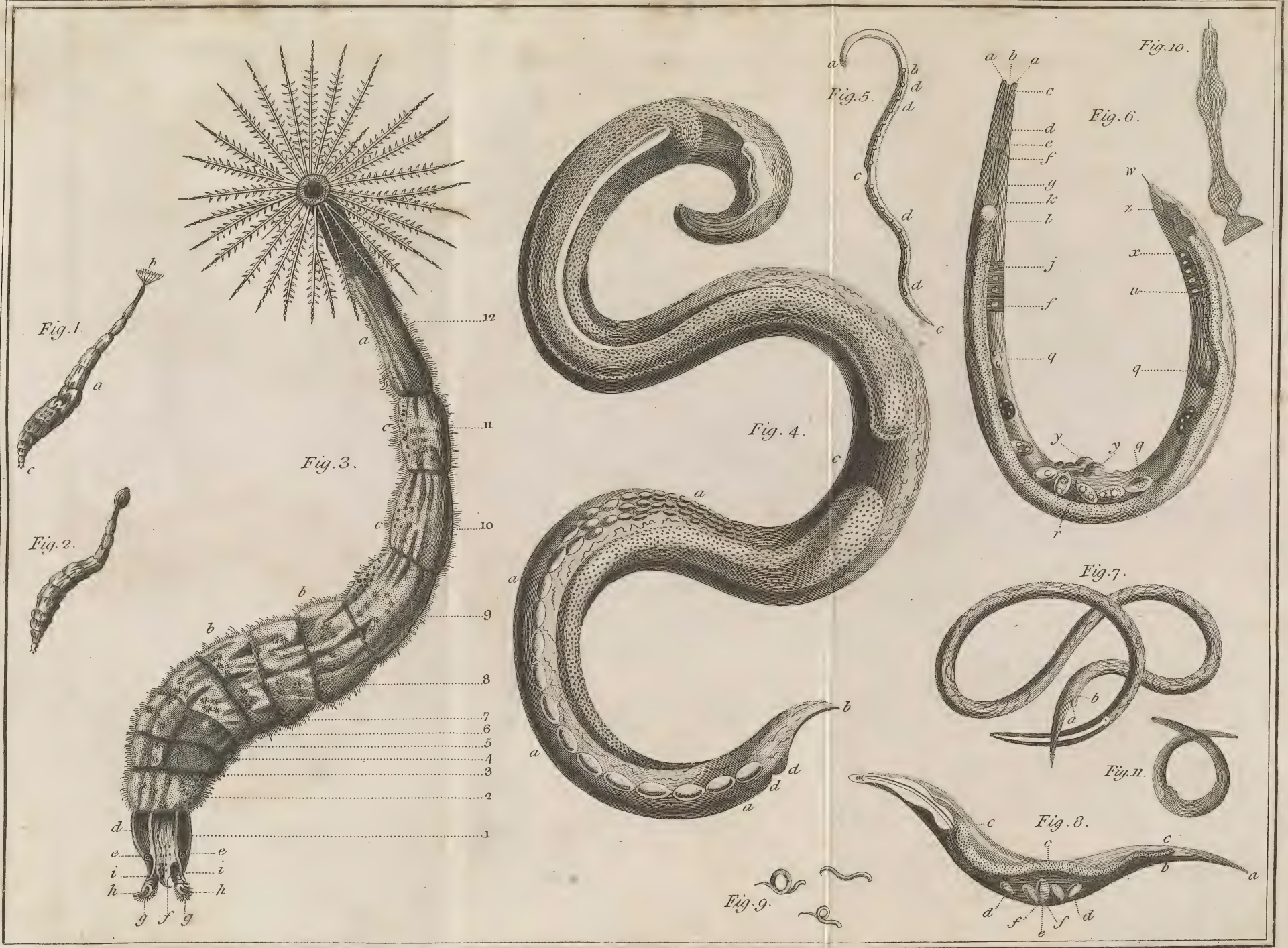
extremity; by this means a hollow space is formed, and the bladder of air pent up in it looks like a pearl, Fig. 2, Plate XI. It is by the assistance of this bubble, or little balloon, that the insect raises itself again to the surface of the water. If this bubble escapes, it can replace it from the pulmonary tubes; sometimes large quantities of air may be seen to arise in bubbles from the tail of the worm to the surface of the water, and there mix with the incumbent atmosphere. This operation may be easily seen by placing the worm in a glass full of water, where it will afford a very entertaining spectacle.

The snout is divided into three parts, of which that in the middle is immovable; the two other parts grow from the sides of the former; these are moveable, vibrating in a very singular manner, like the tongues of lizards and serpents. The greatest strength of the creature is fixed in these lateral parts of the snout; it is on these that it walks when it is out of the water, appearing as it were to walk on it's mouth, using it, as the parrot does it's beak, to move (climb) with greater advantage.

We shall now consider the external figure of this worm, as it appears with the microscope. It is small towards the head, larger about those parts which may be considered as the thorax, it then grows smaller, converging at the abdomen, terminating in a sharp tail, surrounded with hairs in the form of the rays of a star.

This worm, the head and tail included, has twelve annular divisions, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Fig. 3, Plate XI. It's skin resembles the covering of those animals that are provided with







with a crustaceous habit, more than it does that of naked worms or caterpillars; it is moderately hard, and like the rough skin called shagreen, being thick set with a number of grains, evenly distributed. The substance of the skin is firm and hard, and yet very flexible.

On each side of the body are nine spiracula, or holes, for the purpose of respiration; there are no such holes visible on the tail ring *a*, nor on the third ring counting from the head; for at the extremity of the tail there is an opening for the admission and expulsion of air: in the third ring the spiracula are very small, and appear only under the skin, near the place where the embryo wings of the future fly are concealed. It is remarkable that caterpillars, in general, have two rings without these spiracula; perhaps, because they change into flies with four wings; whereas this worm produces a fly that has only two.

The skin has three different shades of colour; it is adorned with oblong black furrows, with spots of a light colour, and orbicular rings, from which there generally springs a hair, as in the figure before us, only the hair that grows on the insect's side is represented; besides this there are here and there some other larger hairs *c c*. The difference of colour in this worm arises from the quantity of grains in the same space; for in proportion as there is a greater or lesser quantity of these, the furrows and rings are of a deeper or paler colour.

The head *d* is divided into three parts, and covered with a skin, the grains on which are hardly discernible. The eyes are rather protuberant, and lie forwards near the snout. It has also

two small horns *i i* on the fore-part of the head. The snout is crooked, and ends in a sharp point as at *f*; but what is altogether singular and surprizing, though no doubt wisely contrived by the great and Almighty Architect, is, that this insect's legs are placed near the snout, between the sinusses, in which the eyes are fixed. Each of these legs consists of three joints, the outermost of which is covered with hard and stiff hairs like bristles. From the next joint there springs a horny bone *h h*, which the insect uses as a kind of thumb; the joint is also of a black substance, between bone and horn in hardness; the third joint is of the same nature. To distinguish these particulars, the parts that form the upper sides of the mouth and the eyes must be separated by means of a small fine knife; you may then, by the assistance of the microscope, perceive that the leg is articulated by means of some particular ligaments, with that portion of the insect's mouth which answers to the lower jaw in the human frame. We may then also discern the muscles which serve to move the legs, and draw them up into a cavity that lies between the snout and those parts of the mouth which are near the horns *i i*.

This insect not only walks with these legs at the bottom of the water, but even moves itself on land by means of them; it likewise makes use of them to swim, while it keeps its tail on the surface contiguous to the air, and hangs downward with the rest of the body in the water; in this situation no motion is perceived in it but what arises from its legs, which it moves in a most elegant manner. It is reasonable to conclude from what has been said, that the principal part of the creature's strength lies in these legs: nor will it be difficult for those who are acquainted with the nature of the ancient hieroglyphics (which are now opening so clearly)

clearly) to fix the rank of this insect in animated life, and point out those orders of being, and the moral state through which it receives it's form and habits of life.

The snout is black and hard, the back part is quite solid, and somewhat of a globular form, whereas the front, *f*, is sharp and hollow; on the back part three membranaceous divisions may be observed, by means of which, and the muscles contained in the snout, the insect can at pleasure expand or contract it.

The tail is constructed and planned with great skill and wisdom. The extreme verge, or border, is surrounded by thirty hairs, and the sides adorned with others that are smaller; here and there the large hairs branch out into smaller ones, which may be reckoned as single hairs. These hairs are all rooted in the outer skin, which in this place is covered with rough grains, as may be seen by cutting it off, and holding it up, when dry, against the light, upon a thin plate of glass. By the same mode you will find, that at the extremities of the hairs there are also grains like those of the skin; in the middle of the tail there is a small opening; within it are minute holes, by which the insect takes in and lets out the air it breathes. The hairs are very seldom disposed in so regular a manner as they are represented in Fig. 3; Plate XI. except when the insect floats with the body in the water, and the tail with it's hairs a little lower than the surface, for they are then displayed exactly as delineated in the plate. The least motion downward of the tail produces a concavity in the water, and it then assumes the figure of a wine glass, wide at the top, narrow at the bottom.

The tail serves the larva both for the purposes of swimming and breathing, and it receives through the tail that which is the universal principle of life and motion in animals. By means of these hairs it can stop itself at pleasure when swimming, or remain suspended quietly in the water for any length of time.

The motion of this insect in swimming is very beautiful, especially when it advances with it's whole body floating on the surface of the water, after filling itself with air by the tail. To set out, it first bends the body to the right or left, and then contracts it in the form of the letter S, and again stretches it out in a straight line: by thus alternately contracting and then extending the body, it moves along on the surface of the water. It is of a very quiet disposition, and not disturbed by handling.

These larva are generally to be found in shallow standing waters, about the beginning of June, sooner or later as the summer is more or less favorable; in some seasons they are to be found in great numbers, while in others it is no easy matter to meet with them. They love to crawl on the plants and grass which grows in the water, and are often to be met with in ditches, floating on the surface of the water by means of their tail, the head and thorax at the same time hanging down; and in this situation they will turn over the clay and dirt with their snout and feet in search of food, which is generally a viscous matter that is common in small ponds and about the sides of ditches. This worm is very harmless, contrary to the opinion one might form at first sight, from the surprizing vibratory motion of the legs, which resembles the brandishings of an envenomed tongue or sting. They are most easily killed for dissection in spirit of turpentine.

After

After a certain period they pass into the pupa form; when they are about to change, they betake themselves to the herbs that float on the surface of the water, and creep gently thereon, till at length they lie partly on the dry surface, and partly on the water; when in the larva or pupa state, they can live in water, but can by no means inhabit there when changed into flies: indeed, man also, whilst in the uterus, lives in water, which he cannot do afterwards. When these worms have found a proper situation, they by degrees contract themselves, and, in a manner scarce perceivable, lose all power of moving. The inward parts of the worm's tail now separate from the outmost skin, and become greatly contracted; this probably gives the insect a great deal of pain: by this contraction, an empty space is left in the exterior skin, into which the air soon penetrates.

Thus this insect passes into the pupa state under its own skin, entirely different from that of the caterpillar, which casts off the exterior skin at this time; this change may often be observed to take place in the space of ten or twelve hours, but in what manner it is performed we are ignorant, as it is effected in a hidden unknown way, inwardly within the skin, which conceals it from our view.

Whilst the larva is changing under the skin, the body, head, and tail, separate insensibly from their outward vesture. The legs at this time, and their cartilaginous bones, are, on account of the parts which are withdrawn from them, left empty; the worm loses also now the former skull, the beak, together with the horny bones belonging thereto, which remain in the skin of the exuvia. It is worthy of notice, that the optic nerves separate

also from the eyes, and no more perform their office. The muscles of the rings also in like manner, and a great part of the pulmonary points of respiration, are separated from the external skin. Thus the whole body contracts itself by degrees into a small compact mass. At this time the gullet and the pulmonary tubes cast a coat within the skin. To make this evident, it is necessary to open the abdomen, when the pupa, it's parts, together with the cast off pulmonary pipes, may be clearly seen.

An exact account of all the changes of the interior parts is to be found in Swammerdam's Book of Nature. These changes are best examined by taking the pupa out of the skin, or outside case, when it begins to harden; for as it has not then quite attained the pupa form, and the members are somewhat different from what they will be when in that state, it is more easy to observe their respective situation, than when the pupa is some days older, and has lost the greatest part of the superfluous humours. The pupa is inclosed in a double garment; the interior one is a thin membrane, which invests it very closely; the other, or exterior one, is formed of the outermost hard skin of the larva, within which it performs it's changes in an invisible manner: it is this skin which gives it the appearance of the larva while in the pupa state.

When the time approaches that the hidden insect, now in the pupa form within it's old covering, is to attain the imago, fly, or perfect state, which generally happens in about eleven days after the preceding change, the superfluous humours are evaporated by insensible perspiration. The little pupa is contracted unto the fifth ring of the skin, and the four last rings of the abdomen are filled with air, through the aperture in the respiratory orifice of
the

the tail. This may be seen by exposing the pupa a little while to the rays of the sun, and then putting its tail in water, when you will find it breathe stronger than it did before, and, by expressing an air-bubble out of its tail, and then sucking it in again, will manifestly perform the action of inspiration and expiration. The anterior part of the pupa is drawn back from the skin, and having partly deserted it, the beak, head, and first ring of the breast, the little creature lies still, until its exhaling members have acquired strength to burst the two membranes which surround it.

If the exterior case is opened near this period, a wonderful variety of colour may be perceived through the thin skin which invests the pupa. The colours of many of the different parts are now changed; some parts from aqueous become membranaceous, some fleshy, and others crustaceous. The whole body becomes insensibly shaggy, the feet and claws begin to move: the variations may be accurately observed by opening a pupa every day until the time of change. For this purpose they should be laid on white paper, in an earthen dish; they should also be made somewhat moist, and be kept under a glass: the paper serves the pupa to fix its claw to, when they come forth in the form of a fly. A little water should be poured into the dish, to keep the pupa from drying and suffocation.

When the fly begins to appear, the exterior skin is seen to move about the third and fourth anterior ring; the insect then uses all its efforts to promote its escape, and to quit the interior and exterior skin at one and the same time. The exterior skin is divided into four parts; the insect immediately afterwards breaks
open

open it's inner coat, and casting it off, escapes from the prison in which it was entombed, in the form of a beautiful fly. It is to be observed here, that there is nothing accidental in the breaking of the outermost skin; but it is perfectly ordained by a constant order, always happening in the same manner in all these changes: the skin also is, in those places where it is broke open, so circumstanced by the Author of nature, as if joined together by futures.

When the wings are expanded, the little creature immediately enters into another state of life: for the insect that lived before in water and mud, now visits the fields and meadows, being transported through the air on it's elegant wings.*

The larva à queue de rat † (*musca pendula*, Lin.) is also transformed under the skin, which hardens, and forms a case or general covering to the pupa: two horns are pushed out, while it is in this state, from the interior parts; they serve the purpose of respiration: this larva will be more particularly described in a subsequent part of this chapter.

The insects in this class, that is, those that pass into the pupa state under the skin of the larva, go through a change more (according to M. de Reaumur) than the caterpillar, undergoing a change while under their skin, before they assume the pupa form.

The aquatic larva of the *musca chameleon* retains it's form to the last; but there are many insects that are transformed under
their

* Swammerdam's Book of Nature, pt. 2, p. 58.

† Reaum. 8vo. edit. tom. 4, pt. 2, 11. mem. p. 199, plate 30 and 31.

their skin, which form a cone or case for the pupa. In these the larva loses first it's length; the body becoming shorter, assumes the figure of an egg; and the skin forms a hard and crustaceous case, or solid lodging, for the embryo insect.

OF THE LIBELLULA.

In the libellula, or dragon fly, we have an instance of those insects who are termed in the pupa state semicompleta, that is, who proceed from the egg in the figure which they preserve, till the time comes of assuming their wings, and who walk, act, and eat, as well till that period as afterwards.

Of all the flies which adorn or diversify the face of nature, there are few, if any, more beautiful than the libellula: "they are almost of all colours, green, blue, crimson, scarlet, and white; some unite a variety of the most vivid tints, and exhibit, in one animal, more different shades than are to be found in the rainbow." The larva of the libellula is an inhabitant of the water, the fly itself is generally found hovering on the borders thereof.

vide Myrmecoleon
Libellula
in Cyclopaedia
but vol 401
Entomology
Plate 2

These insects are produced from an egg which is deposited in the water by the parent; the egg sinks to the bottom, and remains there till the young insect finds strength to break the shell. The larva is hexapode, and is not quite so long as the fly; on the trunk are four prominencies, or little bunches, which become more apparent, in proportion as the larva increases in size and changes it's skin. These bunches contain the rudiments of the wings, which adorn the insect when in it's perfect state.

The head of the larva of this insect is exceedingly singular, being covered with a mask which goes over the whole fore part of the head, having proper cavities within to suit the different prominencies of the face, and fits it more exactly than the common mask does the human face; it is of a triangular form, growing smaller towards the bottom: at the bottom there is a knuckle which fits a cavity near the neck; on this part it turns as on a pivot. The upper part of this mask is divided into two pieces, or shutters, which the insect can open or close at pleasure; it can also let down the whole mask whenever it pleases. The edges of the shutters are toothed like a saw. It makes use of the mask to seize and hold its prey.

There is a considerable difference in the shape of these masks in different species of the libellula, some having two claws near the top of it, which they can throw in or out at pleasure, and which make it a very formidable instrument to the insects on which it feeds.

These animals generally live and feed at the bottom of the water, swimming only occasionally; their manner of swimming, or rather moving in the water, is curious, being by sudden jerks given at intervals; but this motion is not occasioned by their legs, which at this time are kept immoveable and close to the body: it is by forcing out a stream of water from the tail, that the body is carried forwards; this may be easily perceived by placing them in a flat vessel, in which there is only just water enough to cover the bottom. Here the action of the water squirted from their tail will be very visible; it will occasion a small current, and give a sensible motion to any light bodies that are lying on the

the surface thereof. This action can only be effected at intervals, because after each ejaculation the insect is obliged to take a fresh supply of water. The larva will sometimes turn it's tail above the surface of the water, and force out a small stream from it, as from a little fountain, and with considerable force.

The pupa differs but very little from the larva; the bunches, containing the wings, grow large, and begin to appear like four short thick wings. It is full as lively as the larva, seeking and enjoying it's food in the same manner: when it is arrived at it's full growth, and is nearly ready to go through it's last change, it approaches the edge of the water, or comes entirely out of it, fixing itself firmly to some piece of wood or other substance by it's acute claws. It remains for some time immoveable; the skin then opens down the back, and on the head; through this opening they exhibit the real head and eyes, and at length the legs; it then creeps forward by degrees, drawing it's wings, and then the body, out of the skin. The wings, which are moist and folded, now expand themselves to their real size; the body is also extended till it has gained it's proper dimensions, which extension is accomplished by the propelling force of the circulating fluids. When the wings and limbs are dry, it enters on a more noble state of life, it now wings the air and seeks it's mate.

What terms expressive may relate
 The change, the splendor of their new-form'd state!
 In ev'ry eye ten thousand brilliants blaze,
 And living pearls the vast horizon gaze;

Gemm'd o'er their heads, the mines of India gleam,
 And heaven's own wardrobe has array'd their frame;
 Where colours blend an ever-varying dye,
 And wanton in their gay exchanges vie.

The females of the gall insect, which have no wings, pass through no transformation; while the male, which has two wings, passes through the pupa state before it becomes a fly. The only change which takes place in the female gall insect (and which is, however, a very considerable one) is this, that after a certain time it fixes itself to the branch of the tree, without being able to detach itself; it afterwards increases much in size, and becomes like a true gall; the female, by remaining thus fixed, for the greater part of her life, to the place where she was first seen, has very little the appearance of an animal; it is in this period of their life that they grow most, and produce their young, while they appear a portion of the branch they adhere to; and what is more singular, the larger they grow the less they look like animals, and while they are employed in laying thousands of eggs, one would take them for nothing but mere galls. The genera of gall insects is very extensive; they are to be found on almost every shrub and tree.

The pucerons, to arrive at their perfect state, pass through that of the semicomplete pupa, and their wings do not appear till they have quitted their pupa state; but as in all the families of pucerons there are many who never become winged, we must not forget to observe, that these undergo no transformation, remaining always the same, without changing their figure, though they increase in size, and change their skin. It is remarkable,

that amongst insects of the same kind some individuals should be transformed, while others are not at all changed: these insects will be considered more fully in another part of this chapter.

Mr. Reaumur * has shewn that the spider fly (*hyppobosca equina*, Lin.) lays so large an egg, that the fly which proceeds from it is as big as the mother, though the egg does not increase the least in size from the time it is first laid. The insect proceeds also from the egg in the imago, or fly state; it is probably transformed in the egg, for Mr. Reaumur has found it in the pupa state therein, and having boiled some of their eggs which had been laid for some days, he found the insect in the form of an oval ball, similar to that the pupa of flies with two wings are generally found in. De Geer thinks that the egg itself is a true larva, which, when it is born, has nothing else to do but to disengage its limbs, &c. from the shell which covers it; and he thinks this the more probable, because there is no embryo seen in this egg, but it is entirely filled with the insect; he has also perceived a contracting and dilating motion in the egg, while it was in the belly of the mother, and immediately after it was laid; circumstances which do not agree with a simple egg.

As Mr. Bonnet † has attempted to give a theory of these various changes, the following extract from it will, I hope, prove agreeable to the reader; it will at least tend to render his ideas of this wonderful subject clearer, and will probably open to his mind many new sources of contemplation.

F f 2

An

* Reaumur, tom. 6, mem. 14.

† Bonnet *Considerations sur les corps organisés.* Contemplation of Nature, &c.

An insect that must cast off it's exuvia, or moult five times before it attains the pupa state, may be considered as composed of five organized bodies, inclosed within each other, and nourished by common viscera, placed in the center: what the bud of the tree is to the invisible buds it contains, such is the exterior part of the caterpillar to the interior bodies it conceals in it's bosom.

Four of these bodies have the same essential structure, namely, that which is peculiar to the insect in it's larva or caterpillar state: the fifth body is that of the pupa. The respective state of these bodies is in proportion to their distance from the center of the animal; those that are farthest off have most consistence, or unfold themselves soonest.

When the exterior body has attained it's full growth, that interior one which is next in order is considerably unfolded; it is then lodged in too narrow a compass, therefore it stretches on all sides the sheath which covers it; the vessels which nourish the external covering, being broken by this violent distension, cease to act, the skin wrinkles and dries up; at length it opens, and the insect is cloathed with a new skin, and new organs.

The insect generally fasts for a day or two preceding each change; this is probably occasioned by the violent state in which it then is, or it may be necessary to prevent obstructions, &c. let this be as it may, the insect is always very weak after it has changed it's skin, the parts being as yet affected by the exertions they have gone through. The scaly parts, as the head and legs, are almost entirely membranaceous, and imbrued with a fluid that insinuates itself between the two skins, and thus facilitates their

their separation; this moisture evaporates by degrees, all the parts acquire a consistence, and the insect is then in a condition to act.

The first use that some caterpillars, who live on leaves, make of their new form, is to devour greedily their exuvia; sometimes they do not wait till their jaws have acquired their full strength; some have been seen to gnaw the shell from which they proceeded, and even the eggs of such caterpillars as have not been hatched.

When we have once formed the idea that all the exterior parts are inlaid, or included one within the other, the production of new organs does not appear so embarrassing, being nothing more than a simple developement; but it is more difficult to form any conception of the changes that happen in the viscera before and after the transformation, the various modifications they undergo eluding our researches. We have already observed, that a little before the change the caterpillar rejects the membrane that lines the intestinal bag: this bowel has hitherto digested only gross food, whereas it must hereafter digest that which is very delicate: a fluid that circulates in the caterpillar, from the hind part towards the head, circulates a contrary way after transformation. Now if this inversion is as real as observation seems to indicate, how amazing the change the interior parts of the animal must have undergone! When the caterpillar moults, small clusters of the tracheal vessels are cast off with the exuvia, and new ones are substituted in their room; but how is this effected, how are the lungs replaced by other lungs? The more we
endeavour

endeavour to investigate this subject, the more we find it is enveloped in darkness.

Whilst the powers of life are employed conformable to the laws of Divine Providence, to change the viscera, and give them a new form, they are also unfolding divers other organs, which were useless to the insect while in the larva state, but which are necessary to that which succeeds. That these interior operations of life may be carried on with greater energy, the animal is thrown into a kind of sleep; during this period, the corpus crassum is distributed into all the parts, in order to bring them to perfection, while the evaporation of the superfluous humours makes way for the elements of the fibres to approach each other, and unite more closely. The little wounds in the inside, which have been occasioned by the rupture of the vessels, are gradually consolidated; those parts which had been violently exercised, recover their tone, and the circulating fluids insensibly find their new channel. Lastly, many vessels are effaced, and turned into a liquid sediment, which is rejected by the perfect insect.

When these various changes are considered, we are surprized at the singularity of the means the AUTHOR of NATURE has made choice of, in order to bring the different species of animals to perfection; and are apt to ask, why the caterpillar was not born a moth? why it passes through the larva and pupa state? why all insects that are transformed do not undergo the same change? These, and a variety of questions that may be started concerning the esse and essence of those existences which appear before us, derive their solution from the general system which is unknown to us. If all were to arrive at perfection at once, the chain

chain would be broken, the creature unhappy, and man most of all.

Amongst insects, some are produced such as they will be during their whole lives; others come forth inclosed in an egg, and are hatched from this in a form that admits of no variation; many come into the world under a form which differs but little from that which they have when arrived at an age of maturity; some again assume various forms, that are more or less remote from that which constitutes their perfect state; lastly, some go through part of these transformations in the belly of the mother, and are born of an equal size with their parent.

By these various changes, a single individual unites within itself two or three different species, and becomes successively the inhabitant of two or three worlds: and how great is the diversity of it's operation in these various abodes! Let us also consider what riches we should have been deprived of, if the silk-worm had been born in it's perfect state.

Since it has been shewn that the larva or caterpillar is really the moth, crawling, eating, and spinning, under the form of the worm, and that the pupa is only the moth swathed up, it is clear that they are not three selfs, or three persons, but that the same individual feels, tastes, sees, and acts by different organs, at different periods of it's life, having sensations and wants at one time, which it has not at another; these wants and sensations always bearing a relation to the organs which excite them.

ON THE RESPIRATION OF INSECTS.

As respiration is one of the most important actions in the life of every animal, great pains have been taken by many naturalists to investigate the nature of this action in insects; to prove its existence, and explain in what manner it is carried on. Malpighi, Swammerdam, Reaumur, and Lyonet, have discovered in the caterpillar two air-vessels placed the whole length of the insect, these they have called the tracheæ; they have also shewn that an infinite number of ramifications proceed from these, and are dispersed through the whole body; that the tracheal vessels communicate with particular openings on the skin of the caterpillar, termed spiracula; there are nine of these on each side of the body. These vessels seem calculated for the reception of air; they contain no fluids, are of a cartilaginous nature, and when cut preserve their figure, and exhibit a well-terminated opening. Notwithstanding this discovery, the existence of respiration has not been proved in many species of insects, and the mechanism thereof is very obscure in all; and it is no more surprizing, that respiration does not exist in the embryo state of insects, than in that of other animals, where we find that respiration, which after their birth is absolutely necessary for their existence, to be by no means so before it.

M. de Reaumur thought that the air entered by the spiracula into the trachea, but did not come out by the same orifice, and consequently that the respiration of insects was carried on in a manner totally different from that of other animals, that the air was expired through a number of small holes, or pores, which are to be found in the skin of the caterpillar, after having been conducted

conducted to them through the extremities of the finer ramifications of the tracheal vessels: whereas M. Bonnet, in consequence of a great variety of experiments, supposed that the inspiration and expiration of the air was through the spiracula, and that there was no expiration of air through the pores of the skin. These experiments were made either by plunging the caterpillars into water, or anointing them with fat and greasy substances, some all over, others only partially. The number of small bubbles which are observed to cover the surface of their bodies, when they are immersed in water, does not arise from the air which is included within, and then proceeding from them, but they are formed by the air which is lodged near the surface of their bodies, in the same manner that it is about all other substances. To render the experiments more accurate, and prevent the air from adhering to the skin, before he plunged the caterpillars in water he always brushed them over with an hair pencil; after this, very few air bubbles will be found on their bodies when they are immersed in water.

A caterpillar will remain a considerable time under water, without destroying the principle of life; and they also recover, in general, soon after they are taken out. To know whether a few only of the spiracula might not be sufficient for the purposes of respiration, he plunged some partially in water, so that only two or more spiracula remained in the open air: in these cases the caterpillar did not become torpid as it did when they were all immersed in water.

One caterpillar, upon which M. Bonnet made his experiments, lived eight days suspended in water, with only two of its anterior

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spiracula

spiracula in the air; during this time he observed, that when the insect moved itself, little streams of bubbles issued from the anterior spiracula on the left side; from this and many other experiments it appeared to him, that amongst all the eighteen spiracula, the two anterior and the two posterior are of the greatest use in respiration.* Sometimes, when the mouths of these have been stoppered with oil, the caterpillar has fell into convulsions. If the posterior part has been oiled, that part will become paralytic. Notwithstanding these experiments, and many more which have been made, the subject is far from being decided, and many still doubt whether there is any respiration in insects similar to our's, at least at certain periods of their life.

This opinion seems to be further confirmed by the experiments of M. Lyonet. He placed several of the large musk beetle, probably the *cerambyx moschatus*, under a glass, where he had been burning sulphur, and which he kept burning while they were there; and though the vapour was so thick that he could not see them, and that he kept them therein more than half an hour, they did not seem in the least incommoded.†

When we consider the great solidity of the cases, or cones, of the pupas of different insects, it is not easy to conceive how they can live several months under the earth, in spaces so confined, and almost impervious to the air. If respiration was absolutely necessary to their existence, and indeed if they did respire, the same situation seems to preclude a continuance of the operation, as the air would soon be corrupted, and unfit for the offices of life.

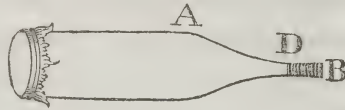
* Philos. Transf. vol. xlv. p. 300.

† Lesser Theologie des Insectes, tom. I, p. 124. Ibid, p. 126.

life. As the trachea are divided and subdivided to a prodigious degree of minuteness, it has been conjectured by some writers, that they may act as so many sieves, which, by separations properly contrived, filtrate the air, and so furnish it to the body of different degrees of purity and subtilty, agreeable to the purposes and nature of the various parts. The experiments that have been made with the air-pump are by no means conclusive; the injury the insect sustains when the atmospheric pressure is taken from the body, does not prove that it inspired and expired the air that we have removed; it only shews that an incumbent pressure is necessary to their comfortable existence, as it prevents the fluids from disengaging themselves in an aerial form, and as it counterballances and re-acts on the principle of life, and by keeping the action thereof in proper tone and order, confines and regulates it's energies.

Though it is difficult to ascertain whether some insects respire, at least at certain periods of their existence, yet there are others to whom the inspiration and expiration of air seems absolutely necessary: there are many aquatic insects who are obliged to keep their tails suspended on the surface of the water for this purpose. To prove this, keep the tail under water, and you will perceive the insect to be agitated and uneasy, and to seek for some opening to expose this part to the air; if it finds none, it soon goes to the bottom and dies. Some aquatic beetles resist the trial for a considerable time, while their larva can only support it for a few minutes. There is a circumstance which renders all experiments on this subject with insects doubtful and difficult, namely, the vast tenaciousness of the life principle in the lower orders of animated nature, and it's diffemination through their whole frame.

M. Mufchenbrock inclosed the pupa of a moth in a glass tube, nearly of the same size with the moth itself.



The end A of the tube was drawn out into a capillary form, the other end was covered with a piece of wet bladder, to exclude the air; the capillary end was then plunged in water, which rose to D. He placed the capillary part of the tube before a microscope, on a small micrometer, in order to observe any motion or change in the situation of the water; as it is evident the expiration or inspiration of air by the insect would make it rise or fall alternately.

In the first experiment he observed a small degree of motion at distant intervals, not above two or three times in an hour; in a second experiment on another subject, he could observe no motion at all. He then placed some pupas under the receiver of an air-pump, in water which he had previously purged of it's air; on exhausting the air from the receiver, he observed one bubble to arise in a part near the tail, and a few near the wings. The pupa did not swell under the operation; on the contrary, on letting in the air, it was found to be diminished in a small degree, but in less than a quarter of an hour it recovered it's former figure. Mr. Martinet published at Leyden, in 1753, a dissertation, in which, it is said, he has clearly proved, by a number of experiments, that the pupa of the caterpillar and some other insects do not respire: I have not seen the work.

Among

Among the insects in which the respiration seems to be most clearly proved, is the larva à queue de rat (*musca pendula*, Lin.); these live under water in the mud, to which they affix themselves; though they live under water, the respiration of fresh air is necessary to their existence; for this purpose they are furnished with a tail, which often appears of an excessive length relative to their body; the body is seldom more than three quarters of an inch in length, while the tail is frequently more than four inches; it is composed of two tubes, which run one into the other, something similar to the tubes of a refracting telescope. Besides this, the materials of which the tubes are composed are capable of a great degree of extension. When the tail is at its full length, it is exceeding small, not being larger near the extremity than a horse-hair; there is a little knob at the end, which is furnished with small hairs, to extend on the water, something similar to those at the tail of the *musca chameleon*.

In the body of the larva are two large tracheal vessels; these air-vessels extend from the head to the tail, and terminate in the respiring tubes, and receive the air from them. The larva quits the water when the time of its transformation approaches, and enters in the earth, where the skin hardens and forms a case, in which the pupa is formed; soon after the change, four tubes, or horns, are seen projecting from the case: these M. de Reaumur supposes to be organs for communicating air to the interior parts of the insect; they are connected with little bladders which are found filled with air, and by which it is conveyed to the spiracula of the pupa. The larva of gnats, and other small aquatic insects of the same kind, are furnished with small tubes, that play on the surface of the water, and convey the air from thence to the insect.

insect. Many other singularities are to be found among the aquatic larva.

The reader will not, I hope, be displeased with another account of the *musca pendula*, drawn up by a naturalist who knew how to render every subject interesting, but more particularly those of this science. "Being out, says he, on an excursion with some friends, we were struck with the appearance of a little puddle of reddish water, the surface of which was in continual motion; on taking up some of this water, we found a number of dirty shapeless animals, which had much the appearance of a common maggot, but much uglier; they were brown, thick, and short, and furnished with tails. I ordered them to be laid down on the grass, and dispatched a servant for some clear water, and then began to explain their nature, origin, and properties.

"I had often informed my companions that none of the winged insects were hatched in their perfect state from the egg, but that they all are first produced in the form of worms, maggots, or caterpillars; or, in other words, covered with skins, under which they live, move, and eat, and have the appearance of very different animals from their parents; they were not, therefore, surprized, when I informed them that the creatures before us were not in their ultimate state, but were the produce of the bee fly, an insect resembling the common humble bee in form, size, and colour, but having only two wings; whereas the bee has four, and a sting, which is wanting to the fly.

"This fly is instructed by the Universal Guide and Guardian of nature, to lay it's eggs about the edges of the water. It's young, while

while in the worm state, are to live and feed in water; but the female parent cannot deposit her eggs in that element without perishing in the attempt. She lays them on dry land, near the proper place of residence of her young, and they are instructed by the same Guide to place them in such a situation, that as soon as they are hatched they make their way to the water; and finally, when they have acquired their full growth, and the animal within is ready to burst forth into a new life, and enjoy the regions of the air, it again quits the water, that this great event may be finished at land.

“As the servant was now returned with a little water, I just observed, that though respiration is necessary to all animal life, yet it is variously performed in the several species; and that thus, while man and the generality of other animals respired by the mouth, this creature does it by the tail. The insects we were examining were about half an inch long, and their tails near an inch: I proportioned the water in the glass to this measure in depth, and on our throwing some of them into it, their bodies naturally sunk with the head downwards, and while they seemed searching after food about the bottom, the extremities of their tails were seen just above the water, and in continual motion.

“My companions, who have long since learnt to make every observation of this kind a source of adoration to the supreme creator, disposer, and preserver of all things, were admiring the care of his providence in contriving thus amazingly that a poor reptile should not be suffocated while it fed. When I ordered a pint more water to be thrown into the glass, they all cried out, at first, against my destroying these unhappy animals; but their admiration

miration was raised much higher than before, when I observed that they would receive no harm, for they had a power of lengthening their tail about an inch, but that they were not left without means of life in a much more increased depth of water; on adding a quart more water, it was soon found that the apparent tail of the insect was a mere tube, containing within it another much smaller, yet sufficiently large for the passage of all the air that was necessary to this animal, a fine slender pipe being immediately darted up out of this, and extended to the new surface; on raising the water two inches higher the pipe was immediately lengthened again as far as was necessary, and so on till the limits of the glass suffered us to carry the experiment no further."

OF THE GENERATION OF INSECTS.

One of the greatest mysteries in nature is generation, or that power by which the various species of animals, &c. are propagated; by which one single individual gives birth to thousands, or even millions of individuals like itself; all formed agreeable to proportions which are only known to that ADORABLE WISDOM which has established them. We shall never be able to form any adequate conception of this power, till we are acquainted with the principles of life, and can trace their various gradations in different orders of beings. Many ancient philosophers, from a misconception and perversion of the sentiments of the more ancient sages, imagined that insects were produced from corrupt and putrefied substances; that organized bodies, animated with life, and framed in a most wonderful manner, owed their origin to mere chance! Not so the most ancient sages; they taught that every degree of life must proceed from the fountain and source of
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all life, and that therefore, when manifested, it must be replete with infinite wonders; but then they also shewed, that if in it's descent through the higher orders of being it was perverted, it would be manifested in loathsome forms, and with filthy propensities; and that according to the degree of reception of the Divine goodness and truth, or the perversion thereof, new forms of life would be occasionally manifested. The gloom of night still wraps this subject in obscurity; will the dawn of day ere long gild the horizon of the scientific world? or is the time of it's breaking forth yet far from us? Be this as it may, insects will be found to conform to that general law of order which runs through the whole of animated nature, namely, that the conjunction of the male and female is necessary for the production of their offspring. Where we cannot ascertain causes, we must be content with facts.

Though insects are, like larger animals, distinguished into male and female, yet in some classes there is a kind of mules, partaking of neither sex, though originating themselves from the conjunction of both: many other particularities relative to the sexes can only be touched upon here.

In many insects the male and female are with difficulty distinguished, and in some they differ so widely, that an unskilful person might easily take the male and female of the same insect for different species; as for instance, in the *phalæna humuli*, *pinaria*, *ruffula*. The dissimilarity is still greater in those insects in which the male has wings and the female none, as in the *coccus lampyris*, *phalæna antiqua*, &c.

In general the male is smaller than the female. The antennæ of the male are, for the most part, larger than those of the female. In some moths, and other insects which are furnished with feathered antennæ, the feathers of the male fly are large and beautiful, while those of the female are small, and scarce to be perceived. Some male beetles are furnished with a horn, which is wanting in the female.

“Pleraque insectorum genitalia sua intra anum habent abscondita, et penes solitarios, sed nonnulla penem habent bifidum: cancri autem et aranei geminos, quemadmodum nonnulla amphibia, et quod mirandum in loco alieno, ut cancer, sub basi caudæ. Araneus mas palpos habet clavatos, qui penes sunt, juxta os utrinque unicum, quæ clavæ sexum nec speciem distinguunt; et fœmina vulvas suas habet in abdomine juxta pectus; heic verò si unquam vere dixeris: res plena timoris amor, si enim proci inauspicato accesserit, fœmina ipsum devorat, quod etiam fit, si non statim se retraxerit. Libellula fœmina genitale suum sub apice gerit caudæ, et mas sub pectore, adeo ut cum mas collum fœmina forcipe caudæ arripit, illa caudam suam pectori ejus adplicet, sicque peculiari ratione connexæ volitent.”

Insects are either oviparous or viviparous; or, in other words, the species is perpetuated, either by their laying of eggs, or bringing forth their young alive. The former is the more general case; there are but few instances of the latter. Those insects which pass through the different transformations already described, cannot propagate till they arrive at their imago or perfect state; and we believe there is seldom any conjunction of the

fexes in other classes till they have moulted, or put off their last skin, the cancri and monoculi excepted.

Mr. de Reaumur mentions six or seven species of two-winged flies that are viviparous, bringing forth worms, which are afterwards transformed into flies. The womb of one of these is singularly curious: it is formed of a band rolled up in a spiral form, and about two inches and a half in length; so that it is seven or eight times longer than the body of the fly, and composed of worms placed one on the side of the other with wonderful art: they are many thousands in number.*

The habits of the pucerons are so very singular, that I cannot pass them over in silence; the more so, as they are a very curious object for the microscope. They are called by various names, the proper one is aphid; that which they are most known by is puceron, though they are sometimes called vine fretters and plant lice. They belong to the hemiptera order. The rostrum is inflected, the antennæ are longer than the thorax, some have four erect wings, others have none at all: towards the end of the belly there are two tubes, from which is ejected that most delicate juice called honey-dew.

The aphides are a very numerous genus; Linnæus has enumerated thirty-three different species, whose trivial names are taken from the plant which they inhabit, though it is probable the number is much larger, as the same plant is often found to support two or three different sorts of aphides.

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* Reaumur Mem. des Insectes, tom. 4, p. 415.

An aphid, or puceron, brought up in the most perfect solitude from the very moment of it's birth, in a few days will be found in the midst of a numerous family; repeat the experiment on one of the individuals of this family, and you will find this second generation will multiply like it's parent, and this you may pursue through many generations.

Mr. Bonnet had repeated experiments of this kind, as far as the sixth generation, which all uniformly presented the observer with fruitful virgins, when he was engaged in a series of new and tedious experiments, from a suspicion imparted by Mr. Trembley in a letter to him, who thus expresses himself: "I have formed the design of rearing several generations of solitary pucerons, in order to see if they would all equally bring forth young. In cases so remote from usual circumstances, it is allowed to try all sorts of means; and I argued with myself, who knows but that one copulation might serve for several generations?" This "WHO KNOWS?" persuaded Mr. Bonnet that he had not sufficiently pursued his investigations. He therefore now reared to the tenth generation his solitary aphides, having the patience to keep an exact account of the days and hours of the birth of each generation. He then discovered both males and females among them, whose amours were not in the least equivocal; the males are produced only in the tenth generation, and are but few in number; that these soon arriving at their full growth, copulate with the females, and that the virtue of this copulation serves for ten successive generations; that all these generations, except the first, from fecundated eggs are produced viviparous, and all the individuals are females, except those of the last generation, among whom some males appear to lay the foundation of a fresh series.

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In order to give a further insight into the nature of these insects, I shall insert an extract of a description of the different generations of them by Dr. Richardson, as published in the Philosophical Transactions, vol. lxi.

The great variety of species which occur in the insects now under consideration, may make an inquiry into their particular natures seem not a little perplexing, but by reducing them under their proper genus, the difficulty is considerably diminished. We may reasonably suppose all the insects, comprehended under any distinct genus, to partake of one general nature; and by diligently examining any particular species, may thence gain some insight into the nature of all the rest. With this view Dr. Richardson chose out of the various sorts of aphides the largest of those found on the rose tree; not only as its size makes it the more conspicuous, but as there are few others of so long a duration. This sort appears early in the spring, and continues late in the autumn; while several are limited to a much shorter term, in conformity to the different trees and plants from whence they draw their nourishment.

1. If at the beginning of February the weather happens to be so warm as to make the buds of the rose tree swell and appear green, small aphides are frequently to be found on them, though not larger than the young ones in summer, when first produced. It will be found, that those aphides which appear only in spring, proceed from small black oval eggs, which were deposited on the last year's shoot; though when it happens that the insects make too early an appearance, the greater part suffer from the sharp weather that usually succeeds; by which means, the rose trees are

are some years in a manner freed from them. The same kind of animal is then at one time of the year viviparous, and at another oviparous.

Those aphides which withstand the severity of the weather seldom come to their full growth before the month of April, at which time they usually begin to breed, after twice casting off their exuvia, or outward covering. It appears that they are all females, which produce each of them a numerous progeny, and that without having intercourse with any male insect; they are viviparous, and what is equally singular, the young ones all come into the world backwards. When they first come from the parent, they are enveloped by a thin membrane, having in this situation the appearance of an oval egg; these egg-like appearances adhere by one extremity to the mother, while the young ones contained in them extend the other, by that means gradually drawing the ruptured membrane over the head and body to the hind feet. During this operation, and for some time after, the fore part of the head adheres, by means of something glutinous, to the vent of the parent. Being thus suspended in the air, it soon frees itself from the membrane in which it was confined; and after it's limbs are a little strengthened, is set down on some tender shoots, and left to provide for itself.

In the spring months there appear on the rose trees but two generations of aphides, including those which proceed immediately from the last year's eggs; the warmth of the summer adds so much to their fertility, that no less than five generations succeed one another in the interval. One is produced in May, which casts off it's covering; while the months of June and July each

each supply two more, which cast off their coverings three or four times, according to the different warmth of the season. This frequent change of their outward coat is the more extraordinary, because it is repeated more often when the insects come the soonest to their growth, which sometimes happens in ten days, where warmth and plenty of nourishment conspired.

Early in the month of June, some of the third generation which were produced about the middle of May, after casting off their last covering, discover four erect wings, much longer than their bodies; and the same is observable in all the succeeding generations which are produced during the summer months, but still without any diversity of sex; for some time before the aphides come to their full growth, it is easy to distinguish which will have wings, by a remarkable fullness of the breast, which in the others is hardly to be distinguished from the body. When the last covering is rejected, the wings, which were before folded up in a very narrow compass, are gradually extended in a very surprizing manner, till their dimensions are at last very considerable.

The increase of these insects in the summer time is so very great, that by wounding and exhausting the tender shoots they would frequently suppress all vegetation, had they not many enemies to restrain them. Notwithstanding these insects have a numerous tribe of enemies, they are not without friends, if those may be considered as such, who are officious in their attendance for the good things they expect to reap thereby. The ant and the bee are of this kind, collecting the honey in which the aphides abound, but with this difference, that the ants are constant visitors, the bee only when flowers are scarce; the ants will suck
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in the honey while the aphides are in the act of discharging it; the bees only collect it from the leaves on which it has fallen.

In the autumn three more generations of aphides are produced, two of which generally make their appearance in the month of August, and the third before the middle of September. The two first differ in no respect from those which are found in summer; but the third differs greatly from all the rest. Though all the aphides which have hitherto appeared were females, in this tenth generation several male insects are found, but not by any means so numerous as the females.

The females have at first the same appearance with those of the former generations, but in a few days their colour changes from a green to a yellow, which is gradually converted into an orange before they come to their full growth; they differ also in another respect from those which occur in summer, for all these yellow females are without wings. The male insects are, however, still more remarkable, their outward appearance readily distinguishing them from this and all other generations. When first produced, they are not of a green colour like the rest, but of a reddish brown, and have afterwards a dark line along the back; they come to their full growth in about three weeks, and then cast off their last covering, the whole insect being after this of a bright yellow colour, the wings only excepted; but after this change to a deeper yellow, and in a very few hours to a dark brown, if we except the body, which is something lighter coloured, and has a reddish cast. The males no sooner come to maturity than they copulate with the females, who in a day or two after their intercourse with the males lay their eggs, generally near the buds.

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Where there are a number crowded together, they of course interfere with each other, in which case they will frequently deposit their eggs on other parts of the branches.

It is highly probable that the aphides derive considerable advantages by living in society; the reiterated punctures of a great number of them may attract a larger quantity of nutritious juices to that part of the tree, or plant, where they have taken up their abode.

In the natural history of insects, new objects of surprise are continually rising before the observer: singular as we have already shewn is the production of the puceron, that of the bee will not be found to be less so; and though this little republic has at all times gained universal esteem and admiration, though they have attracted the attention of the most ingenious and laborious inquirers into nature, yet the mode of propagating their species seems to have baffled the ingenuity of ages, and rendered their attempts to discover it abortive; even the labours and scrupulous attention of Swammerdam were unsuccessful; though, while he was writing his treatise on bees, his daily labour began at six in the morning, and from that hour till twelve he continued watching their operations, his head in a manner dissolving into sweat, under the irresistible ardour of the sun; and if he desisted at noon, it was only because his eyes then became too weak, as well from the extraordinary afflux of light and the use of glasses, to continue longer exercised by such minute objects. He spent one month entirely in examining, describing, and representing their intestines; and many months on other parts: employing whole days in making observations, and whole nights in registering

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them, till at last he brought his treatise of bees to the wished-for perfection, a work which all the ages, from the commencement of natural history to our own times, have produced nothing to equal, nothing to compare with it.* “Read it, says the great Boerhaave, consider it, and then judge for yourself.” Reaumur, however, thought he had in some measure removed the veil, and explained their manner of generating: he supposes the queen bee to be the only female in the hive, and the mother of the next generation; that the drones are the males, by which she is fecundated; and that the working bees, or those that collect wax on the flowers, that knead it, and form from it the combs and cells, which they afterwards fill with honey, are of neither sex. The queen bee is known by its size, being generally much larger than the working bee or the drone.

“High on her throne, the bright imperial queen
Gives the prime movement to the state machine:
She in the subject sees the duteous child;
She the true parent, as the regent mild;
With princely grace invested sits elate,
Informs their conduct, and directs the state.

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The clustering populace obsequious wait,
Or spread the different orders of the state;
Here greet the labourer on the toilsome way,
And to the load their friendly shoulders lay;
Or frequent at the busy gate arrive,
And fill with amber sweets their fragrant hive;

Or

* Boerhaave's Life of Swammerdam.

Or seek repairs to close the fractur'd cell ;
Or shut the waxen womb where embryos dwell.
The caterers prompt a frugal portion deal,
And give to diligence a hasty meal ;
In each appointed province all proceed,
And neatest order weds the swiftest speed ;
Dispatch flies various on ten thousand wings,
And joy throughout the gladsome region rings."

Mr. Schirach, a German naturalist, affirms that all the common bees are females in disguise, in which the organs that distinguish the sex, and particularly the ovaria, are obliterated, or at least from their extreme minuteness have escaped the observer's eye ; that every one of those bees, in the earlier period of its existence, is capable of becoming a queen bee, if the whole community should think it proper to nurse it in a particular manner, and raise it to that rank : in short, that the queen bee lays only two kinds of eggs, those that are to produce the drones, and those from which the working bees are to proceed.

Mr. Schirach made his experiments not only in the early spring months, but even as late as November. He cut off from an old hive a piece of the brood comb, taking care that it contained worms which had been hatched about three days. He fixed this in an empty hive, together with a piece of honey-comb, for food to his bees, and then introduced a number of common bees into the hive. As soon as these found themselves deprived of their queen and their liberty, a dreadful uproar took place, which lasted for the space of twenty-four hours. On the cessation of this tumult, they betook themselves to work, first proceeding to the

construction of a royal cell, and then taking the proper methods for feeding and hatching the brood inclosed with them; sometimes even on the second day the foundation of one or more royal cells were to be perceived; the view of which furnished certain indications that they had elected one of the inclosed worms to the sovereignty. The bees may now be left at liberty.

The final result of these experiments is, that the colony of working bees being thus shut up with a morsel of brood comb, not only hatch, but at the end of eighteen or twenty days produce from thence one or two queens, which have to all appearance proceeded from worms of the common sort, which appears to have been converted by them into a queen, merely because they wanted one. *

From experiments of the same kind, varied and often repeated, Mr. Shirach concludes that all the common working bees were originally of the female sex; but that if they are not fed, lodged, and brought up in a particular manner while they are in a larva state, their organs are not developed; and that it is to this circumstance attending the bringing up of the queen, that the extension of the female organs is effected, and the difference in her form and size produced.

Mr. Debraw has carried the subject further, by discovering the impregnation of the eggs by the males, and the difference of the size among the drones or males; though indeed this last circumstance was not unknown to Mess. Maraldi and Reaumur. Mr. Debraw watched the glass hives with indefatigable attention,
from

* Shirach. Histoire Naturelle des Abeilles.

from the moment the bees, among which he took care there should be a large number of drones, were put into them; to the time of the queen's laying her eggs, which generally happens the fourth or fifth day, he observed, that on the first or second day (always before the third) from the time the eggs are placed in the cells, a great number of bees fastening themselves to one another hung down in the form of a curtain, from the top to the bottom of the hive; they had done the same at the time the queen deposited her eggs, an operation which seems contrived on purpose to conceal what is transacting: however, through some parts of this veil he was enabled to see some of the bees inserting the posterior part of their bodies each into a cell, and sinking into, but continuing there only a little while. When they had retired, it was easy to discover a whitish liquor left in the angle of the basis of each cell, which contained an egg. In a day or two this liquor was absorbed into the embryo, which on the fourth day assumes it's worm or larva state, to which the working bees bring a little honey for nourishment, during the first eight or ten days after it's birth. When the bees find the worm has attained it's full growth, they leave off bringing it food, they know it has no more need of it; they have still, however, another service to pay it, in which they never fail, it is that of shutting it up in it's cell, where the larva is inclosed for eight or ten days: here a further change takes place; the larva, which was heretofore idle, now begins to work, and lines it's cell with fine silk, while the working bee incloses it exteriorly with a wax covering. The concealed larva then voids it's excrement, quits it's skin, and assumes the pupa; at the end of some days the young bee acquires sufficient strength to quit the slender covering of the pupa, tear the wax covering of it's cell, and proceeds a perfect insect.

To

To prove further that the eggs are fecundated by the males, and that their presence is necessary at the time of breeding, Mr. De-braw made the following experiments. They consist in leaving in a hive the queen, with only the common or working bees, without any drones, to see whether the eggs she laid would be prolific. To this end, he took a swarm, and shook all the bees into a tub of water, leaving them there till they were quite senseless; by which means he could distinguish the drones, without any danger of being stung: he then restored the queen and working bees to their former state, by spreading them on a brown paper in the sun; after this he replaced them in a glass hive, where they soon began to work as usual. The queen laid eggs, which, to his great surprise, were impregnated; for he imagined he had separated all the drones, or males, and therefore omitted watching them; at the end of twenty days he found several of his eggs had, in the usual course of changes, produced bees, while some had withered away, and others were covered with honey. Hence he inferred, that some of the males had escaped his notice, and impregnated part of the eggs. To convince himself of this, he took away all the brood comb that was in the hive, in order to oblige the bees to provide a fresh quantity, being determined to watch narrowly their motions after new eggs should be laid in the cells. On the second day after the eggs were placed in the cells, he perceived the same operation that was mentioned before, namely, that of the bees hanging down in the form of a curtain, while others thrust the posterior part of the body into the cells. He then introduced his hand into the hive, broke off a piece of the comb, in which there were two of these insects; he found in neither of them any sting (a circumstance peculiar to the drones); upon dissection, with the assistance of a microscope, he discovered the

the four cylindrical bodies which contain the glutinous liquor, of a whitish colour, as observed by Maraldi in the large drones. He was therefore now under a necessity of repeating his experiments, in destroying the males, and even those which might be suspected to be such.

He once more immersed the same bees in water, and when they appeared in a senseless state, he gently pressed every one, in order to distinguish those armed with stings from those which had none, and which of course he supposed to be males: of these last he found fifty-seven, and replaced the swarm in a glass hive, where they immediately applied again to the work of making cells, and on the fourth or fifth day, very early in the morning, he had the pleasure to see the queen bee deposit her eggs in those cells: he continued watching most part of the ensuing days, but could discover nothing of what he had seen before.

The eggs, after the fourth day, instead of changing in the manner of caterpillars, were found in the same state they were the first day, except that some were covered with honey. A singular event happened the next day, about noon; all the bees left their own hive, and were seen attempting to get into a neighbouring hive, on the stool of which the queen was found dead, being no doubt slain in the engagement. This event seems to have arisen from the great desire of perpetuating their species, and to which end the concurrence of the males seems so absolutely necessary; it made them desert their habitation, where no males were left, in order to fix a residence in a new one, in which there was a good stock of them.

To

To be further satisfied, Mr. Debrow took the brood comb, which had not been impregnated, and divided it into two parts; one he placed under a glass bell, No. 1, with honey-comb for the bees food, taking care to leave a queen, but no drones, among the bees confined in it: the other piece of brood-comb he placed under another glass bell, No. 2, with a few drones, a queen, and a proportionable number of common bees. The result was, that in the glass, No. 1, there was no impregnation, the eggs remained in the same state they were in when put into the glass; and on giving the bees their liberty on the seventh day, they all flew away, as was found to be the case in the former experiment; whereas in the glass, No. 2, the very day after the bees had been put into it, the eggs were impregnated by the drones, and the bees did not leave their hives on receiving their liberty.

The editor of the Cyclopædia says, that the small drones are all dead before the end of May, when the larger species appear, and supersede their use; and that it is not without reason, that a modern author suggests that a small number of drones are reserved, to supply the necessities of the ensuing year; but that they are very little, if any, larger than the common bee.

It does not enter into our plan to notice further in this place the wonders of this little society. A bee-hive is certainly one of the finest objects that can offer itself to the eyes of the beholder. It is not easy to be weary of contemplating those workshops, where thousands of labourers are constantly employed in different works. While one party is employed in collecting the matter of the wax, and filling their magazines with it, others work this wax, and build with it their cells; this is again polished and
6 perfected

perfected by others: some wander abroad to extract the honey from the flower, which they afterwards deposit in cells, as well for the necessities of the day as those of the inclement season: some cover with wax the cells that contain the honey, which is to be preserved for the ensuing winter: others feed the young, &c. with various other employments, too numerous to be inserted here.

The eggs of insects are contained and arranged in the body of the insect, in vessels which vary in number and figure in different species; the same variety is found in the eggs; some are round, others oval, some cylindrical, and others nearly square; the shells of some are hard and smooth, while others are soft and flexible. It is a general rule, that eggs do not increase in size after they are laid; among insects we find, however, an exception to this; the eggs of the mouches a scie (tenthredo, Linn.) increase after they are laid, but their shell is soft and membranaceous.

The eggs of insects differ in their colours; some may be found of almost every shade, of yellow, green, brown, and even black. The eggs of the lion puceron* (hemerobius, Linn.) are a very singular object, and cannot have escaped the eye of any person who is conversant among the insects which live on trees; though of the many who have seen them, few, if any, have found what they really were. It is common to see on the leaves and pedicles of the leaves of the plumb-tree, and several other trees, as also on their young branches, a number of long and slender filaments, running out to about an inch in length; ten or twelve of these

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are

* Reaumur Hist. de Insectes, vol. xi. p. 142.

are usually seen placed near one another, and a vast number of these clusters are found on the same tree; the end of each of these filaments is terminated by a sort of swelling, or tubercle, of the shape of an egg. They have generally been supposed to be of vegetable origin, and that they were a sort of parasitical plant, growing out of others. There is a time when these egg-like balls, which terminate every one of these filaments, are found open at the ends; in this state they very much resemble flowers, and have been figured as such by some authors, though they are only the eggs out of which the young animals had been hatched and made their escape. If these eggs are examined by a microscope, a worm may be discovered in them; or they may be put in a box, in which, in a proper time, they will produce an insect, which, when viewed with a microscope, will be found to be the true lion puceron.

Divine Providence instructs the insects, by a lower species of perception, to deposit their eggs in situations where their young ones will find the nourishment that is most convenient for them. Some deposit their eggs in the oak leaf, producing there the red gall; others chuse the leaf of the poplar, which swells into a red node or bladder; to a similar cause we are indebted for the red knob which is often seen on the willow-leaf, and the three pointed protuberances upon the termination of the juniper branches. The leaves of the veronica and cerasium are drawn into a globular head by the eggs of an insect lodged therein. The phalæna neustria glues it's eggs with great symmetry and propriety round the smaller branches of trees. Fig. 1, Plate X. represents a magnified view of the nest of the eggs taken off the tree after the caterpillar had eat it's way through them; the strong ground-work of

of gum, by which they are connected and bound together, is very visible in many places; they strengthen this connection further, by filling up all the intervening space between the eggs with a very tenacious substance. The eggs are crustaceous, and similar to those of the hen. Fig. 3, Plate X. is a vertical section of the eggs, shewing their oval shape. Fig. 5 is an horizontal section through the middle of the egg. It is not easy to describe the beauty of these objects, when viewed in the lucernal microscope; the regularity with which they are placed, the delicacy of their texture, the beautiful and ever-varying colours which they present to the eye, give the spectator a high degree of rational delight.

Some deposit their eggs in the back of other insects; these, after having passed through their various transformations, become what is termed an ichneumon fly. In the Lapland Alps there is a fly covered with a downy hair, called the rhen-deer gad-fly, *oestrus tarandi*, Linn. It hovers all day over these animals, whose legs tremble under them; they prick up their ears, and flee to the mountains covered with ice and snow, to escape from a little hovering fly, but generally in vain, for the insect but too soon finds an opportunity to lodge its egg in the back of the deer; the worm hatched from this egg perforates the skin, and remains under it during the whole winter; in the following year it becomes a fly. The *oestrus bovis* is an equal terror to oxen; the *hippobosca equina* to horses; *oestrus ovis* * to the sheep, &c.

* *Oestrus ovis* in naso five sinu frontis animalium rumentantium. Linn.

The gnat, the ephemera, the phryganea, the libellula, hover over the water all day to drop their eggs, which are hatched in the water, and continue there all the time they are in the larva form. The mass formed by the gnat resembles a little vessel set afloat by the insect; each egg is in the form of a keel; these are curiously connected together. The gnat lays but one egg at a time, which she lays upon the water in a very ingenious and simple manner; she stretches her legs out, and crosses them, thus forming an angle to receive and hold the first egg; a second egg is soon placed next the first; then a third, and so on, till the base is capable of supporting itself. The spawn of this insect is sometimes above an inch long, and one-eighth of an inch in diameter, and tied by a little stem, or stalk, to some stick or stone. Sometimes they are laid in a single, sometimes in a double spiral line; sometimes transversely. Many moths cover their offspring with a thick bed of hair, which they gather from their own body; while others cover them with a glutinous composition, which, when hard, protects them from moisture, rain, and cold. The gall-flies, it has been already observed, know how to open the nerves of the leaves, to deposit thus their eggs in a place which afterwards serves them for a lodging, and a magazine of food. The solitary bees and wasps prepare an habitation for their little ones in the earth, placing there a proper quantity of food for them, when they proceed from the egg. The voracious and cruel spider is attentive and careful of it's eggs; the wolf spider carries them on it's back in a little bag formed of it's filk; it cannot be separated from them but by violence, and exhibits the most marked signs of uneasiness when deprived of them: a circumstance the more remarkable, as they love to destroy each other, and even carry on their courtships with a diffidence and

caution unknown in any other species of animals. The history of bees and wasps, and their care and attention to their offspring, is so well known, that I may with propriety pass it over here, and proceed just to notice the industrious ant, whose paternal affection and care is not so well known. They are not satisfied with placing their eggs in situations made on purpose, and to raise or rear them till they come to their nymph or pupa state; but they even extend their care to the pupa, removing them from their nest to the surface of the earth, whenever the weather is fine, that they may receive the benignant influence of the sun, carrying them back again as soon as the air begins to grow cold. If any accident disturbs their nest, and disperses the pupas, they manifest the greatest signs of distress, seeking the lost and scattered pupas, placing them in some sheltered place while they repair the nest, when they again transport them to it.* Many other curious particulars might be related relative to this industrious insect, as their uniting together in scooping out earth, and transporting the materials for the construction of their nests, and the curious structure of the nest itself, which, though it appears piled up at random, will be found, on stricter examination, to be a work of art and design, with other circumstances which are too long to be enumerated here.

The perception by which insects are actuated, so as to secure in the most wonderful manner their offspring, merits the most attentive consideration, and strongly marks the regular proceedings of Divine Providence: they do not deposit them at random, but place them in situations agreeable to their nature, and in places where they will meet with such supplies of nourishment, as
will

* Lessers Theologie des Insectes, tom. I, p. 143.

will contribute to their perfection, and be acceptable to the several appetites of their young ones. This is beautifully illustrated by Mr. Brooke, in his philosophical poem on Universal Beauty, where, speaking on this subject, he says,

Each as reflecting on their primal state,
 Or fraught with scientific craft innate,
 With conscious skill their oval embryo shed,
 Where native first their infancy was fed;
 Or on some vegetating foliage glued;
 Or o'er the flood they spread their future brood;
 A slender cord the floating jelly binds,
 Eludes the wave, and mocks the warring winds.
 O'er this their sperm in spiral order lies,
 And pearls in living ranges greet our eyes.
 In firmest oak they scoop a spacious tomb,
 And lay their embryo in the spurious womb:
 Some flowers, some fruit, some gums, or blossoms chuse,
 And confident their darling hopes infuse;
 While some their eggs in ranker carnage lay,
 And to their young adapt the future prey.

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All by their dam's prophetic care receive
 Whate'er peculiar indigence can crave:
 Profuse at hand the plenteous tables spread,
 And various appetites are aptly fed.
 No less each organ suits each place of birth,
 Finn'd in the flood, or reptile o'er the earth.

Each

Each organ apt to each precarious state,
As for eternity design'd complete.

Of all the productions of nature, insects are the most numerous, and multiply most; their fecundity is prodigious, their multiplication astonishing; the vegetables which cover the surface of the earth bear no proportion to their multitudes, every plant supporting a number often of scarce perceptible creatures; of the fatal effects of their prodigious multiplication, our fruit trees, &c. are too often a deplorable testimony. On the continent whole provinces often languish in consequence of the dreadful havock made by the minute, but innumerable, hosts of insects.

The following is an experiment of M. Lyonet on the generation of a moth which comes from the chenille a brosse: out of a brood of 350 eggs, that he had from a single moth of this kind, he took 80, from which he got, when they were arrived at their perfect state, 15 females; from whence he deduces the following consequence: if 80 eggs give 15 females, the whole brood of 350 would have produced 65; these 65, in supposing them as fertile as their mother, would have produced 22,750 caterpillars, among which there would have been at least 4265 females, who would have produced for the third generation 1,492,750 caterpillars. This number would have been much larger if the number of females among those which were selected by M. Lyonet had been greater. M. de Geer counted in the belly of a moth 480 eggs, reducing these to 400, if supposing one-fourth only of these to be females, and as fruitful as their mother, they will give birth to 40,000 caterpillars for the second generation; and for the third, supposing all things equal, four millions of caterpillars. It is not surprising,

surprizing, therefore, that they are found so numerous in years which are favorable to their propagation. But the Creator of all things has for our sakes limited this abundant multiplication, by raising up hosts of enemies, who, besides sickness, &c. destroy the superfluous quantity.

The following is a calculation of the fecundity of the queen bee, by M. de Reaumur: he found that she laid in the two months of March and April 12,000 eggs, so that the swarm which left the hive in May consisted of near 12,000 bees, all produced from one mother; but these calculations all fall short of those which were made by Leeuwenhoek on a fly, whose larva feeds on flesh, putrid carcases, &c. which multiply prodigiously, and that in a short space of time. One of these laid 144 eggs, from which he got as many flies in the first month; so that supposing one-half of these to be females, in the third month we shall have 746,496, all produced in three months from one fly.

OF THE FOOD OF INSECTS.

Insects feed upon all kinds of vegetable and animal substances; there is scarce any production of these two kingdoms which does not serve for food to some kind of insect. They may, therefore, be considered under two heads, those which live on vegetables, and those which are supported by animal food; each insect knows the food which is proper to sustain its life, it knows where to seek it, and how to procure it. It has been already observed, that several insects, when arrived at a state of perfection, feed after their transformation upon food totally different from that which nourished them in their larva state; yet these are informed
by

Among those which feed on vegetables, some sink themselves in the earth, destroy the roots of the plants, and do considerable injuries to our gardens, &c. The food of others is dry and hard; they pierce the wood, reduce it to powder, and then feed on it; some, as the *coffus*, destroy and attack the trees, while the food of others more delicate is the leaves. The leaf is eat in a different manner by different insects; some eat the whole substance, while others feed only on the parenchymous parts, which are contained between it's superficial membranes, forming within side the leaf paths and galleries. These insects are not always content with the leaf, but attack the flower also: even this food is too gross for many; the bee, the butterfly, the moth, as well as several species of flies, feed only on the honey, or finer juices, which they collect from flowers. Fruits, grains, and corn, are not free from them; they divide them with us, and often deprive us of large quantities. We are continually finding the larva of some insect in pears, plumbs, peaches, and other fruit; there is, indeed, no part of a plant which does not serve as food to different insects; some have one kind of plant marked out for them to inhabit and feed on, others have another assigned to them, on which, and no other, they will feed; each has it's appropriate food, and though the parent animal eats not at all, or lives upon food entirely different, yet she is guided, as we have already observed, to deposit her eggs on that peculiar shrub or plant that will be food for her young; while some, more voracious than the rest, feed upon all with equal avidity. The *grylus migratorius*, a few years since, poured out of Tartary in such

L1 quantities,

quantities, as to lay waste great part of Europe, producing almost unequalled calamities, swarming in such multitudes as to cloud the air, destroying all the vegetables; in Sweden the cattle perished with hunger, and the men were forced to abandon their country, and fly to the neighbouring regions.* The far greater part feed only, however, on one species of plant, or at most on those which are similar to it; and the same species may always be found on the same plant.

Mr. de Reaumur says, that the caterpillar, which infests and feeds upon the cabbage, destroys in twenty-four hours more than twice it's weight. If larger animals required a proportionable quantity, the earth would not be able to nourish it's inhabitants.

A great number of insects reject vegetable, and live on animal food; some seeking that which is beginning to putrefy, while others delight in that which is entirely putrid; others again are nourished by the most filthy puddles, and disgusting excrements; some attack and feed on man himself, while others are nourished by his victuals, his cloaths, his furniture: some prey upon insects of another species, others attack their own, and harass each other with perpetual carnage.

Every animal has it's appropriate lice, which feed on and infest it. M. Rhedi has given an accurate account of a great number of these little noxious creatures, accompanied with figures; but, as if it were not sufficient that these creatures should dwell and live on the external part of the body, and suck the blood of the animal

* Select Dissertations from the *Amœnitates Academicæ*, vol. I, p. 398.

animal that they infest, we find another species of insects seeking their food in the more vital parts, and feeding on the flesh of the animal, while full of life and health. M. de Reaumur has given an history of a fly (*oestrus bovis*) which lives upon the backs, and feeds on the flesh of young oxen and cows, where it produces a kind of tumor. The fly lodges it's eggs in the flesh, by making a number of little wounds, in each of which it deposits eggs, so that every wound becomes a nest, the eggs of which are hatched by the heat of the animal. Here the larva finds abundant food at the same time that it is protected from the changes of the weather; and here they stay till they are fit for transformation. The parts they inhabit are often easy to be discovered by a kind of lump, or tumor, which they form by their ravages; this tumor suppurates, and is filled with matter; on this disgusting substance the larva feeds, and his head is always found plunged in it. When the time of their metamorphosis is ready, the larva falls upon the ground, and seeks a convenient place for the operations of the ensuing change.

There is a species (*oestrus hæmorrhoidalis*) which deposit their eggs in the rectum of horses, it being in the intestines of these only that they can be nourished. M. Vallisnieri has given an account of the introduction of these eggs into the horse, as observed by a friend of his who was looking at some that were feeding quietly in a meadow: on a sudden they began to leap and jump, roll themselves on the ground, then run, beat about their tails, and were otherwise violently agitated; persuaded that these extraordinary motions were produced by a fly that was buzzing about them, he observed them narrowly. The fly not being able to succeed in it's attacks on these, quitted them, and flew towards

a mare, who was separated from the rest, making less noise than before, and here it was more successful; it passed under the tail, and by causing an itching near the anus, forced the mare to push out the edge of the intestine, to open it, and then to enlarge the opening; the fly profited by this opportunity, and deposited it's eggs in the fold of the intestine; in a little time the mare became almost furious, and was agitated in the most violent manner for a quarter of an hour, when she began to grow more easy.

Nearly allied to the preceding are the following curious observations of an ingenious naturalist on the ichneumon fly. "As I was observing, says he, one day some caterpillars which were feeding voluptuously on a cabbage-leaf, my attention was attracted towards a part of the plant, about which a little fly was buzzing on it's wing, as if deliberating where to settle: I was surprised to see the herd of caterpillars, creatures of twenty times it's size, endeavouring in an uncouth manner, by various contortions of the body, to get out of it's way, and more so, whenever the fly poised on the wing as if going to drop; at length the creature made it's choice, and seated itself on the back of one of the largest and fairest of the cluster; it was in vain the unhappy reptile endeavoured to dislodge the enemy. If the caterpillar had shewn terror on the approach of the fly, it's anguish at intervals now seemed intolerable, and I soon found that it was in consequence of the strokes, or wounds, given by the fly. At every wound the poor caterpillar wreathed and twisted it's whole frame, endeavouring to disengage itself, by shaking off the enemy, sometimes aiming it's mouth towards the place; but it was all in vain, it's little but cruel tormentor kept it's place. When it had inflicted thirty or forty of these wounds, it took it's flight with a
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visible triumph; in each of these wounds the little fly had deposited an egg. I took the caterpillar home with me, to observe the progress of the eggs which were thus placed in its body, taking care to give it a fresh supply of leaves from time to time; it recovered to all appearance in a few hours from the wounds it had received, and from that time, for the space of four or five days, seemed to live comfortably, feeding voraciously. The eggs were all hatched into small oblong voracious worms, which fed from the moment of its appearance on the flesh of the caterpillar, in whose body they were inclosed, and seemingly without wounding the organs of respiration or digestion; and when they had arrived at their full growth, they eat their way out of the sides of the animal, at the same time destroying it. The caterpillar thus attacked by the larva of the ichneumon never escapes, its destruction is infallible; but then its life is not taken away at once; the larva, while it is feeding thereon, knows how to spare the parts which are essential to its life, because its own is at that time tied up in that of the caterpillar. No butterfly is produced from it; the worms that feed on the wretched creature are no sooner out of its body, than every one spins its own web, and under this they pass the state of rest necessary to introduce them to their winged form." *

Of this strange scene it is difficult for us to form a proper judgment; we are unacquainted with the organs of the caterpillar, ignorant of the nature of its sensations, and therefore we cannot be assured what may be the effects of that which we see it suffer. "It is wisdom to suppose we are ignorant, while we know the Creator cannot be cruel." From revelation we learn, that man

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* Inspector, No. 64.

is the mean through which life is conveyed to the creatures of this lower world; that by sinking into error, and fostering evil, he perverts his own life, and corrupts all that which proceeds from him: so that the effects are the same on the orders beneath him, as would arise to the world if a continual cloud was placed between us and the sun, depriving us at once of the salutary effects of it's invigorating heat and cheering light.

Lastly, many insects feed upon others; nay, some even upon their own species. The numbers of these two kinds are very numerous; and it is amongst these that we find the traces of the greatest art and cunning, as well in attack as in defence. Some, indeed, use main force alone, others employ address and cunning. Every body is acquainted with the dexterous arts of the spider, the curious web he spins, it's regular construction, and the central position of the spider, in order to watch more effectually the least motion that may be communicated to it's tender net. The art and history of the formica leo are also well known, and a description of them would lead us too great lengths. Those who would wish to pursue this subject further, will find much satisfaction in consulting the works of Reaumur and De Geer.

OF THE HABITATION OF INSECTS.

Insects may be divided, with respect to their habitations, into two classes, aquatic and terrestrial.

Standing waters are generally filled with insects, who live therein in different manners. There are, 1. Aquatic insects which remain always on the superficies of the water, or which at least
plunge

plunge themselves therein but rarely. 2. Others that live only in the water, and cannot subsist out of it. 3. Many, after having lived in the water while in the larva and pupa state, come out afterwards with wings, and become entirely terrestrial. 4. Some undergo all their transformations in the water, and then become amphibious. 5. Others again are born and grow in the water, but undergo their pupa state on dry land, and after they are arrived at their perfect state live equally in air and water. 6. Lastly, there are some who live at the same time part in the water, and part on land, and which after their transformation cease to be aquatic.

Among the insects which remain on the superficies of the water, are some spiders, which run with great address and agility, without moistening their feet or their body; when they repose themselves, they extend their feet as much as possible. There are also aquatic bugs, which swim, or rather run, on the water with great velocity, and by troops; another bug walks very slowly on the water; the gyrinus moves very swiftly, and in circles. There is a species of podura * which live in society, and are often accumulated together in little black lumps. Those insects which always live in the water are generally born with the figure which they preserve during their whole lives, as the monoculi, crabs, several kinds of water-mites, &c.

The number of those which, after having lived in the water, leave it when in a winged state, is very great: among these we may reckon the libellula, the ephemera, the phryganea, culices, tipulæ, and some species of muscæ. All these, when in the larva and

* De Geer Discours sur les Insectes, tom. 2, p. 103.

and pupa state, live in the water; but when they have assumed their perfect form, they are entirely terrestrial, and would be drowned therein.

The notonecta, the nepa or aquatic scorpion, &c. never quit the water till they have passed through all their transformations, when they become amphibious, generally quitting it in the evening.

The water-beetles, of which there are many species, remain in the water all day, but towards evening come upon the ground and fly about, but plunge themselves again in the water at the approach of the rising sun. The larvæ of these insects are entirely aquatic; but when the time of their pupa state arrives, they take to the earth, where they make a spherical case: so that these insects are aquatic as larva, terrestrial as pupa, and amphibious in the imago state.

We find an instance of an insect that lives at the same time in the water and the air, in the singular larva described by M. de Reaumur, *Memoires de l'Acad.* in 1714, p. 203. It has the head and tail in the water, while the rest of the body is continually kept above the surface. In order to support itself in this singular position, it bends the body, bringing the head near the tail, raising the rest above the water, and supporting itself against some fixed object, as a plant, or against the borders of the pond; or, if it is placed in a glass vessel, against the sides of the vessel; and if the glass be inclined gently, so that the water may nearly cover the larva, it immediately changes its position, in order that part of the body may be kept dry.

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At the baths of Abano, a small town in the Venetian state, there is a multitude of springs, strongly impregnated with sulphur, and of a boiling heat. In the midst of these boiling springs, within three feet, of four or five of them, there is a tepid one about blood-warm. In these waters, not only the common potamogetous and confervas, or pond-weeds and water-mosses, are found growing in an healthy state; but numbers of small black water-beetles are seen swimming about, which die on being taken out and plunged suddenly into cold water.*

Many insects that live under the surface of the earth crawl out on certain occasions, as the julus, scolopendra, and the oniscus; they are also often to be found under stones, or pieces of rotten wood. Some insects remain underground part of their life, but quit that situation after their change; as do some caterpillars, many of the coleopterous class, &c. We have already taken notice that numbers delight to dwell in filth and nastiness. The formica leo forms it's habitation in the sand, as well as many spiders; one of these forms a hole in the sand, and then lines it with a kind of silk, to prevent it's crumbling away; it generally keeps on the watch near the mouth of the hole, and if it perceives a fly, runs at it with such velocity, as seldom to fail in it's attempt of seizing it, and then carries it to it's little den.

Another spider, discovered by Mr. l'Abbé Sauvage,† burrows in the earth like a rabbit, making a hole one or two feet deep, of a regular diameter, and sufficiently large to move itself with ease. It lines the whole of it, either to keep the ground from tumbling

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* Jones's Physiolog. Disquisitions, p. 171.

† Histoire de l'Acad. 1758, p. 26.

in, or in order to perceive more regularly at the bottom what happens at the mouth, at which it forms a kind of door, made of different layers of earth, connected together by threads, and covered with a strong web of a close texture; the threads are prolonged on one side, and fixed to the ground, so as to form a strong joint; the door is hung in such a manner, as always to fall by it's own gravity. One of these cases, or nests, is in her Majesty's cabinet at Kew.

Insects are found no where so numerous as in trees and plants, where they find abundant food. They dwell 1. in the roots; 2. in the wood; 3. in the leaves, and in the galls which grow upon the leaves and branches; 4. in the flowers; 5. in the fruits and grains. It would be too tedious to enumerate the various species of these inhabitants; many particular observations have been already noticed; it has also been mentioned, that some inhabit the most fœtid substances they can find, while others dwell with and live on the larger animals; so that it only remains just to mention some of those in whom industry and art is more strongly marked to our eyes than in others.

Among the solitary bees there are so many curious circumstances to be described, that a single volume would not suffice to contain the particulars; we shall here only relate such as concern their habitations. One of these forms it's nest under ground, which is composed of several cells artfully let into each other, but not covered with a common inclosure; each cell consists of two or three membranes, inexpressibly fine, and placed over each other. The cavity, in which the nest is placed, is smeared over with a layer of matter, like that of which the cells are formed,
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and apparently similar to that viscous humour which snails spread in their passage from one place to another, and it is probable that they are formed of the same materials; this substance, though of so delicate a nature, gives them such a degree of consistency, that they may be handled without altering their form. An egg is deposited at the bottom of each cell, where, after it is hatched, the worm finds itself in the midst of a plentiful stock of provision: for in each cell there is placed a quantity of paste, or a kind of wax, which is to serve as food for the worm, and support the wall of the cell. The worm is also instructed so to conduct itself, and eat this food, as to leave sufficient props for supporting the walls of it's apartment.

Many species of these bees content themselves with penetrating into the earth, scooping out hollow cavities therein, polishing the walls, then depositing an egg and a sufficient quantity of provisions.

There is another species, that forms it's nest under ground with remarkable industry; this bee generally makes a perpendicular hole in the earth about three inches deep, and cylindrical till it comes within about three-fourths of an inch of the bottom, when it begins to open it wider; as soon as the bee has given it the suitable proportions, it proceeds to line with tapestry not only the whole inside of it's dwelling, but round the entrance: the substance with which it is lined is of a crimson colour, and looks like satin. From this circumstance Mr. de Reaumur * terms it the tapestry bee. This tapestry, or lining, is formed of fragments of

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* Reaumur Memoires pour l'Histoire des Insectes, edit. 8vo. tom. 6, partie 1, p. 170.

the flowers of the wild poppy, which she cuts out curiously; and then seizing them with her legs, conveys them to her nest. If the pieces are rumpled she straitens them, and then affixes them to her walls with wondrous art; she generally applies two layers of these fragments on each other. If the piece she has cut and transported is too large for the place she intends it for, she clips off the superfluous parts, and conveys the shreds out of the apartment.

After the bee has lined her cell, she fills it nearly half an inch deep with a paste proper to nourish the larva when hatched from the egg; when the bee has amassed a sufficient quantity of paste, she then takes her tapestry, and folds it over the paste and egg, which are by this means inclosed as it were in a bag of paste; this done, she fills up with earth the empty space that is above the bag. There is another bee which does the same with rose leaves, and in the substance of a thick post. A friend of mine had a piece of wood cut from a strong post that supported the roof of a cart-house, full of these cells or round holes, three-eighths of an inch diameter, and about three-fourths deep, each of which was filled with these rose-leaf cases, finely covered in at top and bottom.

The mason bee is so called by Reaumur from the manner of its building its nest. These bees collect with their jaws small parcels of earth and sand, which they glue together with a strong cement, which is furnished from the proboscis; and of this they form a simple but commodious habitation, which is generally placed along walls that are exposed to the south. Each nest resembles a lump of rude earth, of about six or seven inches diameter, thrown against the wall; the labour of constructing so large

large an edifice must be very great, as the bee can only carry a few grains at a time. The exterior form is rude and irregular, but the construction and art exhibited in the interior parts make up for this seeming defect; it is generally divided into twelve or fifteen cells, separated from each other by a thick wall; in each of these an egg is deposited by the parent bee. The cells are not constructed all at once, for when one is finished she places an egg therein, with a sufficient quantity of honey to nourish the larva; she then builds another. When the insect is arrived at a proper state, it penetrates through it's inclosures by means of it's strong jaws. When all the bees have quitted the nest, there are as many holes on the surface thereof as there are cells within. We find no neutral bees among this species, or at least we do not know of any being yet discovered.

Another species of the solitary bee (*apis centuncularis*, Linn.) constructs her nest in pieces of rotten wood, and has therefore been called the carpenter bee.* She divides it into stages, disposing them sometimes in three rows, with partitions curiously left between each; in these she deposits her eggs, with the food necessary for the young ones when hatched. They separate the wood in a very expeditious manner, by dividing it's ligneous fibres, or threads, till they have made a proper sized hole.

The art and sagacity displayed by another bee, † whose nest is constructed of single pieces of leaves, is truly wonderful. The nest itself is cylindrical, formed of several cells, placed one within the other as thimbles are in a hardware shop. The cells consist
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* Geoffroy Hist. abrégée des Insectes, tom. 2, p. 401.

† Reaumur Memoires pour l'Histoire des Insectes, tom. 6, par. 1, p. 122.

of several pieces cut from one leaf, of forms and proportions proper to coincide with the place each is intended to occupy. The outer case, or cover, is formed with equal care and exactness. In a word, says M. Bonnet, there is so much exactness, symmetry, uniformity, and skill, in this little master-piece, that we should not believe it to be the work of a fly, if we did not know at what school she learnt the art of constructing it. In each cell the mother deposits an almost liquid substance, and yet so nicely are the cells formed, as not to suffer any of this substance to be lost. But to see the detail of the works of this bee, and the curious mechanism of its cells, we must refer the reader to Mr. de Reaumur's admirable history of insects.

Of the mason ichneumon wasp* (*spheg*, Linn.). The proceedings of this are totally different from those of the common wasp, though equally curious with them. It generally begins its work in May, and continues at it for the greatest part of June. The true object of her labour seems to be the digging of a hole a few inches deep in the ground; yet in the constructing of this she forms a hollow tube above ground, the base of which is the opening of the hole, and which it raises as high above ground as the hole is deep below; it is formed with a great deal of care, resembling a gross kind of fillagree work, consisting of the sand drawn from the hole. The sand out of which she excavates her cell is nearly as hard as a common stone; this it readily softens with a penetrating liquor, with which she is well provided; a drop or two of it is imbibed immediately by the sand on which it falls, which is instantly rendered so soft, that she can separate and knead

* Reaumur Mém. pour l'Histoire des Insectes, tom. xi. par. 2, p. 9.

knead it with her teeth and fore feet, forming it into a small ball, which she places on the edge of the hole as the foundation-stone of the pillar she is going to erect: the whole of it is formed of such balls, ranged circularly, and then placed one above the other. She leaves her work at intervals, probably in order to renew her stock of that liquor which is so necessary for her operations; these intervals are of short duration; she soon returns to her work, and labours with so much activity and ardour, that in a few hours she will dig a hole two or three inches deep, and raise a hollow pillar two inches high. After the column has been raised a certain height perpendicularly from the hole, it begins to curve a little, which curvature increases till it is finished, though the cylindrical form is maintained: she constructs several of these holes all of the same form, and for the same purpose.

It is easy to see why the hole was dug in the ground; that it was destined to receive an egg; but it is not so easy to perceive why the tube of sand was formed. By attending to the labours of the wasp, one end, however, may be discovered; it will be found to serve the purpose of a scaffold, and that the balls are as useful to the wasp, as materials, &c. to the mason; and are, therefore, placed as much within her reach as possible. She uses them to stop and fill up the hole after she has deposited an egg therein, so that the pillar is then destroyed, and not the least remains left in the nest. The parent wasp generally leaves ten or twelve worms as provision necessary and proper for the growth of the young larva: no purveyor could take better precautions than our wasp, for she has received her instructions from HIM who provides for the necessities of all his creatures. In selecting the

worms, she chuses them of a proper size, that they may be sufficient in quantity, and of an age that will not be in danger of perishing with hunger, in which case they would have been corrupted; she therefore selects them when they have their full growth. It is also observed, that if she chuses a larger sort she gives a less number of them, and so reciprocally.

“ By these and such like instances, every rational mind may confirm itself in favour of a Divine agency; for human reason, if it be so disposed, may collect and be convinced from the various operations in the visible world, that there is a God, and that he is one; * a truth that is proved by innumerable testimonies; for the universe is as a theatre, on which the evidence of the existence of a God and his unity are continually exhibited; and from these it may be seen, that God is the sole operator by and through nature: for it is clear that nature cannot regard uses as the ends of her operations, or dispose such uses into their orders and forms. This is in the power of none but a wise being, and of consequence of none but God, whose wisdom being infinite, can so order and form the universe, as to make it a coherent and uniform work, all promoting and forming a complex of uses in orderly arrangement, for the service of man, who is to be a constituent of heaven: for the Divine Love cannot design any other end besides the eternal happiness of the human race, by the communication of itself, and the Divine Wisdom can produce nothing but uses

* The system one, one Maker stands confess'd,
 The prime, the one, the wond'rous and the blest'd,
 The one in various forms of unity express'd.

Brooke's Universal Beauty, b. iii.

uses for the promotion of that end. By contemplating the world under this enlarged idea, every wise man may discern that the Creator of the universe is one,* and that his essence is love and wisdom;† and that he effects whatsoever is done in nature, by his own operation, through the medium of the various celestial and spiritual hierarchies, gradually descending from the highest orders of this immense chain to the lowest.

Between the lowest and highest degree of corporeal or spiritual perfection, there is an almost infinite number of intermediate degrees: the result of these degrees composes THE UNIVERSAL CHAIN. This unites all beings, connects all worlds, and comprehends all spheres. One SOLE BEING is out of this chain, and that is HE that formed it.† Again, life itself, and consequently the Lord, is the supreme, only, and infinite use; all other existencies in heaven or earth, whether spiritual or natural, are only ultimate effects, or manifestations from that one infinite cause, exhibiting emblems of the ONE, ETERNAL, INFINITE use.

From a retrospective view of this chapter, we may observe a striking difference between man and the lower orders of animal creation. Man is born totally ignorant; so much so, that he has no knowledge even of the mother's breast, till he has been

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* Hence ENDLESS GOOD; hence ENDLESS ORDER springs;

Hence that importance in minutest things;

And endless hence dependence must endure,

BLEST IN HIS WILL, and in his power secure;

Brooke's Universal Beauty, b. vi.

† Bonnet's Contemplation of Nature.

brought acquainted with it by repeated trials; he has no innate ideas, is unable to chuse what is proper for his food; he cannot form his voice to any articulate pronunciation, or to express the affections of love: whereas, the beast, the bird, and the insect, are born to all that knowledge which is necessary for the gratification of those desires, or that love which forms their life; and consequently in the knowledge of every thing relating to their well being, their food, their habitations, the commerce of the sexes, their provision for their young, &c.: from the impulse of the pleasure arising from these innate desires and affections, the larva is also prompted to seek and aspire after a change of it's earthly state. If it were not foreign to the subject in hand, it might be easy to shew, by a variety of reasons, that this imperfection of man at his nativity constitutes his real perfection, and places him infinitely, if I may so speak, above the brute creation: for man is not created relatively perfect, but formed a recipient of all perfection.

From this view of things, we may, however, perceive that animals are born in order, and consequently the Divine agency influences or acts on them more immediately. The same wisdom which has constructed and arranged their various organs with so much art, that they may concur to one determinate end, directs the animal towards this end. Hence it executes with precision the works we so much admire: hence it seems to act as if it was capable of reasoning. It is excited to all this by that ADORABLE MIND which has traced out to every insect it's little circle, as he has marked out to each planet it's proper orbit. When, therefore, we see an insect working a nest, a chrysalis, &c. we should view

it with respect, because we are beholding a scene behind which the SUPREME ARTIST is concealed from our eyes.

We may hence, also, perceive that the operations of insects are the ultimate result of the principles of life, upon their organization, which corresponds to the part they are to act in the grand machine of the world; they are, indeed, but small parts, but then these parts concur to produce one general effect, by their being interwoven with more important ones; so that the thread spun by a caterpillar has it's relations to the universe as well as the ring of Saturn.* But how immense the number of parts, which are interposed between this thread and the ring of Saturn and between SATURN and the worlds of SYRIUS! If the universe is one whole, the thread of the caterpillar will also be connected with the worlds of Syrius. How great must that mind be which can comprehend this immense chain of various relations, and can perceive them all to resolve into UNITY, unity manifested in JEHOVAH JESUS! It behoves us to remain in the place that has been allotted for us, from whence we can only discover some links of the chain. One day we shall discover more, and see things more distinctly: mean while we may consider these proceedings of the insect race, which are so diversified and replete with industry, as an agreeable spectacle that furnishes us with an inexhaustible source of real pleasure, and useful instruction; that leads us to the Author of the universe as it were by the thread of the caterpillar, and which makes us admire in the variety of their means, and in their tendency to the same end, the fecundity and wisdom of the ORDAINING MIND.

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* Bonnet's Contemplation of Nature.

As no insects exceed the termites in their wonderful œconomy, wife contrivances, and stupendous buildings; it will be proper to give the reader some account of them, which we are enabled to do from the excellent paper describing them, which was written by the late Mr. Smeathman, and published in the Philosophical Transactions for the year ..

The termites are represented by Linnæus as the greatest plagues of both Indies, and are indeed every way between the tropics so deemed, from the vast damages they cause, and the losses which are experienced, in consequence of their eating and perforating wooden buildings, utensils, furniture, &c. which are totally destroyed by them, if not timely prevented; for nothing less hard than metal or stone can escape their most destructive jaws.

They have been taken notice of by various travellers, in different parts of the torrid zone; and indeed, where numerous, as is the case in all equinoctial countries and islands that are not fully cultivated, if a person has not been incited by curiosity to observe them, he must have been very fortunate, who, after a short residence, has not been compelled to it for the safety of his property.

These insects have generally obtained the name of ants; it may be presumed, from the similarity in their manner of living, which is in large communities, that erect very extraordinary nests, for the most part on the surface of the ground; from whence their excursions are made through subterraneous passages, or covered galleries, which they build, whenever necessity obliges, or plunder induce

induces them to march above ground, and at a great distance from their habitations, carry on a business of depredation and destruction, scarce credible but to those who have seen it; but notwithstanding they live in communities, and are like the ants omnivorous, though like them at a certain period they are furnished with four wings, and emigrate or colonize at the same season, they are by no means the same kind of insects, nor does their form correspond with that of ants in any one state of their existence.

The termites resemble the ants also in their provident and diligent labour, but surpass them, as well as the bees, wasps, beavers, and all other animals, in the arts of building, as much as the Europeans excel the least cultivated savages. It is more than probable they excel them as much in sagacity, and the arts of government; it is certain they shew more substantial instances of their ingenuity and industry than any other animals; and do, in fact, lay up vast magazines of provisions and other stores; a degree of prudence, which has of late years been denied, perhaps without reason, to the ants.

The communities consist of one male and one female, (who are generally the common parents of the whole, or greater part of the rest) and of three orders of insects, apparently of very different species, but really the same, which together compose great commonwealths, or rather monarchies.

The great Linnæus having seen or heard of but two of these orders, has classed the genus erroneously; for he has placed it among the aptera, or insects without wings; whereas the chief order,

order, that is to say, the insect in its perfect state, having four wings, without any sting, it belongs to the neuroptera, in which class it will constitute a new genus of many species.

The different species of this genus resemble each other in form, in their manner of living, and in their good and bad qualities; but differ as much as birds in the manner of building their habitations or nests, and in the choice of the materials of which they compose them.

There are some species which build upon the surface of the ground, or part above, and part beneath; and one or two species, perhaps more, that build on the stem or branches of trees.

Of every species there are three orders; first, the working insects, which, for brevity, we shall generally call labourers; next the fighting ones, or foldiers, which do no kind of labour; and last of all, the winged ones, or perfect insects, which are male and female, and capable of propagation: these might very aptly be called the nobility, or gentry, for they neither labour, nor toil, nor fight, being quite incapable of either, and almost of self-defence. These only are capable of being elected kings or queens; and nature has so ordered it, that they emigrate within a few weeks after they are elevated to this state, and either establish new kingdoms, or perish within a day or two.

The TERMES BELLICOSUS being the largest species, is most remarkable, and best known on the coast of Africa. It erects immense buildings of well-tempered clay, or earth, which are contrived and finished with such art and ingenuity, that we are

at a loss to say whether they are most to be admired on that account, or for their enormous magnitude and solidity.

The reason that the larger termites have been most remarked is obvious; they not only build larger and more curious nests, but are also more numerous, and do infinitely more mischief to mankind. When these insects attack such things as we would not wish to have injured, we must consider them as most pernicious; but when they are employed in destroying decayed trees, and substances which only incumber the surface of the earth, they may justly be supposed very useful; and for the reason that they are in one sense most pernicious, they are in the other most useful. In this respect they resemble very much the common flies, which are regarded by mankind in general as noxious, and at best as useless beings in the creation.

The nests of this species are so numerous all over the island of Bananas, and the adjacent continent of Africa, that it is scarce possible to stand upon any open place, such as a rice plantation, or other clear spot, where one of these buildings is not to be seen almost close to each other. In some parts near Senegal, as mentioned by M. Adanson, their number, magnitude, and closeness of situation, make them appear like the villages of the natives.

These buildings are usually termed hills, by natives as well as strangers, from their outward appearance, which is that of little hills, more or less conical; generally very much in the form of sugar loaves, and about ten or twelve feet in perpendicular height above the common surface of the ground.

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These hills continue quite bare until they are six or eight feet high; but in time the dead barren clay, of which they are composed, becomes fertilized by the genial power of the elements in these prolific climates, and the addition of vegetable salts and other matters brought by the wind; and in the second or third year, the hillock, if not over-shaded by trees, becomes like the rest of the earth, almost covered with grass and other plants; and in the dry season, when the herbage is burnt up by the rays of the sun, it is not much unlike a very large hay-cock.

Every one of these buildings consists of two distinct parts, the exterior and the interior.

The exterior is one large shell, in the manner of a dome, large and strong enough to inclose and shelter the interior from the vicissitudes of the weather, and the inhabitants from the attacks of natural or accidental enemies. It is always, therefore, much stronger than the interior building, which is the habitable part, divided with a wonderful kind of regularity and contrivance into an amazing number of apartments, for the residence of the king and queen, and the nursing of their numerous progeny; or for magazines, which are always found well filled with stores and provisions.

These hills make their first appearance above ground by a little turret or two, in the shape of sugar loaves, which are run a foot high, or more; soon after, at some little distance, while the former are increasing in height and size, they raise others, and so go on increasing the number, and widening them at the base, till their works below are covered with these turrets, which they
always

always raise the highest and largest in the middle, and by filling up the intervals between each turret, collect them as it were into one dome.

They are not very curious or exact about these turrets, except in making them very solid and strong ; and when, by the junction of them, the dome is completed, for which purpose the turrets answer as scaffolds, they take away the middle ones entirely, except the tops, (which joined together make the crown of the cupola) and apply the clay to the building of the works within, or to erecting fresh turrets for the purpose of raising the hillock still higher ; so that no doubt some part of the clay is used several times, like the boards and posts of a mason's scaffold.

The outward shell, or dome, is not only of use to protect and support the interior buildings from external violence, and the heavy rains, but to collect and preserve a regular degree of genial warmth and moisture, which seems very necessary for hatching the eggs and cherishing the young ones.

The royal chamber, which, on account of it's being adapted for, and occupied by the king and queen, appears to be, in the opinion of this little people, of the most consequence, being always situated as near the center of the interior building as possible, and generally about the height of the common surface of the ground, at a pace or two from the hillock ; it is always nearly in the shape of half an egg, or an obtuse oval within, and may be supposed to represent a long oven.

In the infant state of the colony, it is not above an inch, or thereabouts, in length; but in time will be increased to six or eight inches, or more, in the clear, being always in proportion to the size of the queen, who, increasing in bulk as in age, at length requires a chamber of such dimensions.

The floor is perfectly horizontal, and in large hillocks, sometimes an inch thick and upward of solid clay; the roof also, which is one solid and well-turned oval arch, is generally of about the same solidity, but in some places it is not a quarter of an inch thick; this is on the sides where it joins the floor, and where the doors or entrances are made level therewith, at pretty equal distances from each other.

These entrances will not admit any animal larger than the soldiers or labourers; so that the king, and the queen (who is, when full grown, a thousand times the weight of a king) can never possibly go out.

The royal chamber, if in a large hillock, is surrounded by an innumerable quantity of others, of different sizes, shapes, and dimensions; but all of them arched in one way or another, sometimes circular, and sometimes elliptical or oval.

These either open into each other, or communicate by passages as wide, and being always empty, are evidently made for the soldiers and attendants; of whom, it will soon appear, great numbers are necessary, and of course always in waiting.

These

These apartments are joined by the magazines and nurseries; the former are chambers of clay, and are always well filled with provisions, which to the naked eye seem to consist of the raspings of wood and plants, which the termites destroy, but are found in the microscope to be principally the gums or inspissated juices of plants. These are thrown together in little masses, some of which are finer than others, and resemble the fugar about preserved fruits; others are like tears of gum, one quite transparent, another like amber, a third brown, and a fourth quite opaque, as we see often in parcels of ordinary gums.

These magazines are intermixed with the nurseries, which are buildings totally different from the rest of the apartments; for these are composed entirely of wooden materials, seemingly joined together with gums. They are called nurseries because they are invariably occupied by the eggs and young ones, which appear at first in the shape of labourers, but white as snow. These buildings are exceedingly compact, and divided into many very small irregular-shaped chambers, not one of which is to be found of half an inch in width; they are placed all round the royal apartments, and as near as possible to them.

When the nest is in the infant state, the nurseries are close to the royal chamber; but as in process of time the queen enlarges, it is necessary to enlarge the chamber for her accommodation; and as she then lays a greater number of eggs, and requires a greater number of attendants, so it is necessary to enlarge and increase the number of the adjacent apartments; for which purpose, the small nurseries, which are first built, are taken to pieces,

rebuilt a little farther off a size bigger, and the number of them increased at the same time.

Thus they continually enlarge their apartments, pull down, repair, or re-build, according to their wants, with a degree of sagacity, regularity, and foresight, not even imitated by any other kind of animals or insects.

The nurseries are inclosed in chambers of clay, like those which contain the provisions, but much larger. In the early state of the nest they are not bigger than an hazel-nut, but in great hills are often as large as a child's head of a year old.

The disposition of the interior parts of these hills is very much alike, except when some insurmountable obstacle prevents; for instance, when the king and queen have been first lodged near the foot of a rock, or of a tree, they are certainly built out of the usual form, otherwise pretty nearly according to the following plan.

The royal chamber is situated at about a level with the surface of the ground, at an equal distance from all the sides of the building, and directly under the apex of the hill. It is on all sides, both above and below, surrounded by what may be called the royal apartments, which have only labourers and soldiers in them, and can be intended for no other purpose than for these to wait in, either to guard or serve their common father and mother, on whose safety depends the happiness, and, according to the negroes, even the existence of the whole community.

These

These apartments compose an intricate labyrinth, which extends a foot or more in diameter from the royal chamber on every side. Here the nurseries and magazines of provisions begin, and being separated by small empty chambers and galleries, which go round them, or communicate from one to the other, are continued on all sides to the outward shell, and reach up within it two-thirds or three-fourths of its height, leaving an open area in the middle under the dome, which very much resembles the nave of an old cathedral; this is surrounded by three or four very large gothic-shaped arches, which are sometimes two or three feet high next the front of the area, but diminish very rapidly as they recede from thence, like the arches of aisles in perspective, and are soon lost among the innumerable chambers and nurseries behind them.

All these chambers, and the passages leading to and from them, being arched, they help to support one another; and while the interior large arches prevent them falling into the center, and keep the area open, the exterior building supports them on the outside.

There are, comparatively speaking, few openings into the great area, and they for the most part seem intended only to admit that genial warmth into the nurseries which the dome collects.

The interior building, or assemblage of nurseries, chambers, &c. has a flattish top, or roof, without any perforation, which would keep the apartments below dry, in case through accident the dome should receive any injury, and let in water; and it is never exactly flat and uniform, because they are always adding to it by building more chambers and nurseries: so that the divisions,

or

or columns, between the future arched apartments, resemble the pinnacles upon the fronts of some old buildings, and demand particular notice, as affording one proof that for the most part the insects project their arches, and do not make them by excavation.

The area has also a flattish floor, which lies over the royal chamber, but sometimes a good height above it, having nurseries and magazines between. It is likewise water-proof, and contrived so as to let the water off, if it should get in and run over, by some short way, into the subterraneous passages, which run under the lowest apartments in the hill, in various directions, and are of an astonishing size, being wider than the bore of a great cannon. There is an account of one that was measured, that was perfectly cylindrical, and thirteen inches in diameter.

These subterraneous passages, or galleries, are lined very thick with the same kind of clay of which the hill is composed, and ascend the inside of the outward shell in a spiral manner; and winding round the whole building up to the top, intersect each other at different heights, opening either immediately into the dome in various places, and into the interior building, the new turrets, &c. or communicating thereto by other galleries of different bores or diameters, either circular or oval.

From every part of these large galleries are various small pipes, or galleries, leading to different parts of the building; under ground there are a great many which lead downward, by sloping descents three and four feet perpendicular among the gravel, from whence the labouring termites cull the finer parts, which being
worked

worked up in their mouths to the consistence of mortar, becomes that solid clay, or stone, of which their hills and all their buildings, except their nurseries, are composed.

Other galleries again ascend and lead out horizontally on every side, and are carried under ground near to the surface, a vast distance: for if you destroy all the nests within one hundred yards of your house, the inhabitants of those which are left unmolested farther off, will nevertheless carry on their subterraneous galleries, and invade the goods and merchandizes contained in it by sap and mine, and do great mischief if you are not very circumspect.

But to return to the cities from whence these extraordinary expeditions and operations originate, it seems there is a degree of necessity for the galleries under the hills being thus large, being the great thoroughfares for all the labourers and soldiers going forth or returning upon any business whatever, whether fetching clay, wood, water, or provisions; and they are certainly well calculated for the purposes to which they are applied; by the spiral slope which is given them; for if they were perpendicular, the labourers would not be able to carry on their building with so much facility, as they ascend a perpendicular with difficulty, and the soldiers can scarce do it at all. It is on this account that sometimes a road like a ledge is made on the perpendicular side of any part of the building within their hill, which is flat on the upper surface, and half an inch wide, and ascends gradually like a stair-case, or like those roads which are cut on the sides of hills and mountains, that would otherwise be inaccessible: by which,
and

and similar contrivances, they travel with great facility to every interior part.

Having given some idea of the nests, we now proceed to give a more particular account of the insects themselves, which will be exceedingly necessary to a tolerable acquaintance with their œconomy and management, their manner of building, fighting, and marching, and to a more particular account of their uses in the creation, and of the vast mischief they cause to mankind. There are of every species of termites three orders; of these orders the working insects, or labourers, are always the most numerous; in the *TERMES BELLICOSUS* there seem to be at the least one hundred labourers to one of the fighting insects, or soldiers. They are in this state about one-fourth of an inch long, and twenty-five of them weigh about a grain, so that they are not so large as some of our ants; from their external habit and fondness for wood, they have been very expressively called wood-lice by some people, and the whole genus has been known by that name, particularly among the French. They resemble them, it is true, very much at a distance; they run as fast, or faster, than any other insect of their size, and are incessantly bustling about their affairs.

The second order, or soldiers, have a very different appearance from the labourers, and have been by some authors supposed to be the males, and the former neuters; but they are, in fact, the same insects as the foregoing, only they have undergone a change of form, and approached one degree nearer to the perfect state. They are now much larger, being half an inch long, and equal in bulk to fifteen of the labourers. There is now, likewise, a

most remarkable circumstance in the form of the head and mouth ; for in the former state the mouth is evidently calculated for gnawing and holding bodies ; but in this state, the jaws being shaped just like two very sharp awls a little jagged, they are incapable of any thing but piercing or wounding, for which purposes they are very effectual, being as hard as a crab's claw, and placed in a strong horny head, which is of a nut-brown colour, and larger than all the rest of the body together, which seems to labour under great difficulty in carrying it : on which account, perhaps, the animal is incapable of climbing up perpendicular surfaces.

The third order, or the insect in it's perfect state, varies it's form still more than ever ; the head, thorax, and abdomen, differ almost entirely from the same parts in the labourers and soldiers ; and besides this, the animal is now furnished with four fine large brownish transparent wings, with which it is, at the time of emigration, to wing it's way in search of a new settlement : in short, it differs so much from it's form and appearance in the two other states, that it has never been supposed to be the same animal, but by those who have seen it in the same nest ; and some of these have distrusted the evidence of their senses. It was so long before Mr. Smeathman met with them in the nests, that he doubted the information which was given him by the natives, that they belonged to the same family : indeed, you may open twenty nests without finding one winged one ; for those are to be found only just before the commencement of the rainy season, when they undergo the last change, which is preparative to their colonization. Add to this, they sometimes abandon an outward part of their building, the community being diminished by some accident that is unknown ; sometimes different species of the real ant (formica)

possess themselves by force of a lodgment, and so are frequently dislodged from the same nest, and taken for the same kind of insects. This is often the case with the nests of the smaller species, which are frequently totally abandoned by the termites, and completely inhabited by different species of ants, cockroaches, scolopendræ, scorpions, and other vermin fond of obscure retreats, that occupy different parts of their roomy buildings.

In the winged state they have also much altered their size as well as form. Their bodies now measure between six and seven-tenths of an inch in length, and their wings above two inches and a half from tip to tip, and they are equal in bulk to about thirty labourers, or two soldiers. They are now also furnished with two large eyes placed on each side of the head, and very conspicuous; if they have any before, they are not easily to be distinguished. Probably, in the two first states, their eyes, if they have any, may be small like those of moles; for as they live like these animals always under ground, they have as little occasion for these organs, and it is not to be wondered at that we do not discover them; but the case is much altered when they arrive at the winged state, in which they are to roam, though but for a few hours, through the wide air, and explore new and distant regions. In this form the animal comes abroad during, or soon after, the first tornado, which at the latter end of the dry season proclaims the approach of the ensuing rains, and seldom waits for a second or third shower; if the first, as is generally the case, happens in the night, and brings much wet after it, the quantities that are to be found the next morning all over the surface of the earth, but particularly on the waters, is astonishing; for their wings are only calculated to carry them a few hours; and after the

the rising of the sun, not one in a thousand is to be found with four wings, unless the morning continues rainy, when here and there a solitary being is seen winging its way from one place to another, as if solicitous only to avoid its numerous enemies, particularly various species of ants, which are hunting on every spray, on every leaf, and in every possible place, for this unhappy race, of which, probably, not a pair in many millions get into a place of safety, fulfil the first law of nature, and lay the foundation of a new community.

Not only all kinds of ants, birds, and carnivorous reptiles, as well as insects, are upon the hunt for them, but the inhabitants of many countries eat them.

They are now become, from one of the most active, industrious, and rapacious, from one of the most fierce and implacable little animals in the world, the most innocent, helpless, and cowardly! never making the least resistance to the smallest ant. The ants are to be seen on every side in infinite numbers, of various species and sizes, dragging these annual victims of the laws of nature to their different nests. It is wonderful that a pair should ever escape so many dangers, and get into a place of security. Some, however, are so fortunate; and being found by the labouring insects that are continually running about the surface of the ground under their covered galleries, the little industrious creatures immediately inclose them in a small chamber of clay, suitable to their size, into which at first they leave but one small entrance, large enough for themselves and the soldiers to go in and out, but much too little for either of the royal pair to make use of; and when necessity obliges them to make more entrances,

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they

they are never larger; so that, of course, the voluntary subjects charge themselves with the task of providing for the offspring of their sovereigns, as well as to work and to fight for them, until they shall have raised a progeny capable at least of dividing the task with them.

The business of propagation, however, soon commences; and the labourers having constructed a small wooden nursery, as before described, carry the eggs and lodge them there as fast as they can obtain them from the queen.

About this time a most extraordinary change begins to take place in the queen, to which we know nothing similar, except in the *PULEX PENETRANS* of LINNÆUS, the JIGGER of the West-Indies, and in the different species of *COCCUS COCHINEAL*. The abdomen of this female begins gradually to extend and enlarge to such an enormous size, that an old queen will have it increased so as to be fifteen hundred or two thousand times the bulk of the rest of her body, and twenty or thirty thousand times the bulk of a labourer; the skin between the segments of the abdomen extends in every direction, and at last the segments are removed to half an inch distance from each other, though at first the length of the whole abdomen is not above half an inch. They preserve their dark-brown colour, and the upper part of the abdomen is marked with a regular series of brown bars, from the thorax to the posterior part of the abdomen, while the intervals between them are covered with a thin, delicate, transparent skin, and appear of a fine cream colour, a little shaded by the dark colour of the intestines and watery fluid seen here and there beneath. It is supposed that the animal is upwards of two years old

old when the abdomen is increased to three inches in length: they have sometimes been found of near twice that size. The abdomen is now of an irregular oblong shape, being contracted by the muscles of every segment, and is become one vast matrix full of eggs, which make long circumvolutions through an innumerable quantity of very minute vessels, that circulate round the inside in a serpentine manner, which would exercise the ingenuity of a skilful anatomist to dissect and develope. This singular matrix is not more remarkable for it's amazing extension and size, than for it's peristaltic motion, which resembles the undulating of waves, and continues incessantly without any apparent effort of the animal; so that one part or other alternately is rising and sinking in perpetual succession, and the matrix seems never at rest, but is always protruding eggs to the amount, as have been frequently counted in old queens, of sixty in a minute, or eighty thousand and upwards in one day of twenty-four hours.

These eggs are instantly taken from her body by her attendants, (of whom there always are, in the royal chamber and galleries adjacent, a sufficient number in waiting) and carried to the nurseries, which in a great nest may some of them be four or five feet distant in a strait line, and consequently much farther by their winding galleries. Here, after they are hatched, the young are attended and provided with every thing necessary, until they are able to shift for themselves, and take their share of the labours of the community. The foregoing is an accurate description and account of the *termes bellicosus*, or species that builds the large nests, in it's different states.

Those

Those which build either the roofed turrets, or the nests in the trees, seem, in most instances, to have a strong resemblance to them, both in their form and œconomy, going through the same changes from the egg to the winged state. The queens also increase to a great size when compared with the labourers, but very short of those queens before described. The largest are from about an inch to an inch and a half long, and not much thicker than a common quill. There is the same kind of peristaltic motion in the abdomen, but in a much smaller degree; and as the animal is incapable of moving from her place, the eggs, no doubt, are carried to the different cells by the labourers, and reared with a care similar to that which is practised in the larger nests.

It is remarkable of all these different species, that the working and the fighting insects never expose themselves to the open air, but either travel under ground, or within such trees and substances as they destroy; except, indeed, when they cannot proceed by their latent passages, and find it convenient or necessary to search for plunder above ground: in that case they make pipes of that material with which they build their nests. The larger sort use the red clay; the turret builders use the black clay; and those which build in the trees employ the same ligneous substance of which their nests are composed.

The termites, except their heads, are exceedingly soft, and covered with a very thin and delicate skin; being blind, they are no match on open ground for the ants, who can see, and are all of them covered with a strong horny shell not easily pierced, and are of dispositions bold, active, and rapacious.

Whenever

Whenever the termites are dislodged from their covered ways, the various species of the former, who probably are as numerous above ground as the latter are in their subterraneous passages, instantly seize and drag them away to their nests, to feed the young brood. The termites are, therefore, exceedingly solicitous about the preserving their covered ways in good repair; and if you demolish one of them for a few inches in length, it is wonderful how soon they rebuild it. At first, in their hurry, they get into the open part an inch or two, but stop so suddenly, that it is very apparent they are surprized: for though some run straight on, and get under the arch as speedily as possible in the further part, most of them run as fast back, and very few will venture through that part of the track which is left uncovered. In a few minutes you will perceive them re-building the arch, and by the next morning they will have restored their gallery for three or four yards in length, if so much has been ruined; and upon opening it again, will be found as numerous as ever under it, passing both ways. If you continue to destroy it several times, they will at length seem to give up the point, and build another in a different direction; but if the old one led to some favourite plunder, in a few days will rebuild it again; and, unless you destroy their nest, never totally abandon their gallery. They do considerable damage to houses, &c. They make their approaches chiefly under ground, descending below the foundations of houses and stores at several feet from the surface, and rising again either in the floors, or entering at the bottom of the posts, of which the sides of the buildings are composed, bore quite through them, following the course of the fibres to the top, or making lateral perforations and cavities here and there as they proceed.

While

While some are employed in gutting the posts, others ascend from them, entering a rafter, or some other part of the roof. If they once find the thatch, which seems to be a favourite food, they soon bring up wet clay, and build their pipes, or galleries, through the roof in various directions, as long as it will support them; sometimes eating the palm-tree leaves and branches of which it is composed, and perhaps (for variety seems very pleasing to them) the rattan, or other running plant, which is used as a cord to tie the various parts of the roof together, and that to the posts which support it. Thus, with the assistance of the rats, who, during the rainy season, are apt to shelter themselves there, and to burrow through it, they very soon ruin the house, by weakening the fastenings and exposing it to the wet. In the mean time, the posts will be perforated in every direction, as full of holes as that timber in the bottoms of ships, which has been bored by the worms; the fibrous and knotty parts, which are the hardest, being left to the last.

These insects are not less expeditious in destroying the shelves, wainscoting, and other fixtures of an house, than the house itself. They are continually piercing and boring in all directions, and sometimes go out of the broadside of one post into that of another adjoining to it; but they prefer and always destroy the softer substances the first; and are particularly fond of pine and fir-boards, which they excavate and carry away with wonderful dispatch and astonishing cunning: for, except a shelf has something standing upon it, as a book, or any thing else which may tempt them, they will not perforate the surface, but artfully preserve it quite whole, and eat away all the inside, except a few fibres, which barely keep the two sides connected together; so
that

that a piece of an inch-board, which appears solid to the eye, will not weigh much more than two sheets of pasteboard of equal dimensions, after these animals have been a little while in possession of it. In short, the termites are so insidious in their attacks, that we cannot be too much on our guard against them: they will sometimes begin and raise their works, especially in new houses, through the floor. If you destroy the work so begun, and make a fire upon the spot, the next night they will attempt to rise through another part; and if they happen to emerge under a chest, or trunk, early in the night will pierce the bottom, and destroy or spoil every thing in it before the morning. On these accounts the inhabitants set all their chests and boxes upon stones or bricks, so as to leave the bottoms of such furniture some inches above the ground, which not only prevents these insects finding them out so readily, but preserves the bottoms from a corrosive damp, which would strike from the earth through, and rot every thing therein: a vast deal of vermin also would harbour under, such as cockroaches, centipedes, millipedes, scorpions, ants, and various other noisome insects.

Though the view we have given of the various proceedings of insects in forming their habitations, has already run to some length, we cannot with propriety neglect taking some further notice of the wonderful industry and art which is manifested in these respects by the caterpillar; and more particularly so, as it is by it we obtained the foundations of all our present knowledge of the natural history of insects.

Some species of caterpillars form a kind of hammock, in which they eat and go through their varied changes; while others erect

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a tent,

a tent, under which they live, until they have consumed the surrounding herbs. They then leave their abodes, and pitch their tents in a more fruitful spot.

Many associate together all their lives, others only for a certain period. Those who live together proceed from the same moth who deposited the eggs near each other, or rather laid them in a heap, forming as it were a kind of nest. These are generally hatched in the same day, and live together, constituting a new species of republic, in which all are brethren. They often amount to near six hundred in a family, though they are frequently to be found with only about two hundred. Of these social caterpillars there are some species which never quit the society while they are in a larva state, even placing the chrysalis close together. There are other kinds who associate only for a short period.

Among the vast variety of insects which inhabit the oak, there is a species of caterpillar which live separate till they arrive at a certain age: they then assemble together, and do not quit each other till they attain their perfect state. As the number which are thus assembled is considerable, the nest is also very large. They remain in-doors during the day, not leaving their habitation till sun-set. When they go out, one of the body precedes the rest as a chief, whom they regularly follow: when the leader stops, the rest do the same, and wait till it goes on again, before they recommence their march. The first file generally consists of a single caterpillar, which are succeeded by a double file, these by three in a row, which are then followed by files of five, and so on. They keep exceeding close to each other, not leaving any interval either between the ranks, or those in each rank: all of them

them following their captain in every direction, whether strait or crooked. After they have taken their repast, which is done on the march, they return to their nest in the same order in which they set out.

This mode is followed till they are full grown, when each forms a cone, in which it is changed into a chrysalis. Mr. Bonnet has shewn, that though these caterpillars proceed often very far from their nest, it is by no means difficult for them to get back again, because they spin over all the places in their rout. The first leads the way, the second follows spinning, the third spins after the first and second, and so on with the rest. All these threads form by degrees a small shining track, a little path; and all these paths meet at the nest. To be fully convinced of the use of these threads, let any one but break the continuation of them in some place or other, and he shall see the little caterpillars turn back, as if they were at a loss, till one more daring than the rest restores the communication by spinning new threads.

The reader who is desirous of a fuller information concerning the habits of these, as well as many other insects, must be referred to the laborious and interesting memoirs of M. de Reaumur. Happy if he should, like M. de Geer, be induced thereby to follow the steps of so great a master; he will derive from thence a continual source of new pleasures and increasing delights; and the more he extends the boundaries of his observations, the more he will be convinced that INFINITY is, as it were, impressed on all the works of the Creator.

Different species of caterpillars are often to be found in great numbers on the same tree or plant; but then as they seem to have no connection with each other, and the actions of the one have no influence on the other, they may be considered as solitary; but there are others who seem still more independent of each other, and greater friends to solitude, constructing a lodging, formed of leaves tied together with considerable ingenuity, in which they live as in a hermitage. The operation by which these tie the leaves together, is far surpassed by another kind, who fold and bend one part of the leaf till it meets the other. These are again exceeded by those who roll the leaves which they inhabit. For this purpose, the caterpillar chuses a part of a leaf which it finds in some degree bent: here it establishes its abode, and begins its work, moving the head with great velocity, in a curved line, or rather vibrating it like a pendulum, the middle of the body being the center on which it moves. At each motion of the head a thread is spun, and fixed to that part to which the head seems to be applied. The threads are extended from the bent to the flat part of the leaf, being always adjusted, both in length and strength, to the nature of the leaf, and the curvature which is to be given to it.

M. de Geer attending to the operations of a species of this kind of caterpillar, observed, that at each new thread it spun, the edges of the leaf insensibly approached to each other, and were bent more and more, in proportion as the caterpillar spun new threads; when the last thread that was spun was tight, that which preceded it was loose and floating in the air. To effect this, the caterpillar, after it has fixed a thread to the two edges of the leaf, (and before it spins another) draws it towards itself by the hooks
of

of it's feet, and by this means bends the leaf; it then spins another thread, to maintain the leaf in this position, which it again pulls towards itself, and repeats the operation, till it has bent the leaf in it's whole direction. It now begins again, placing the threads further back upon the bent part of the leaf, and by proceeding in this manner, it is rolled up; when it has finished this business, it strengthens the work, by fastening the ends of the leaf together. The habitation thus formed is a kind of hollow cylinder, open to the light at both ends, the sides of it affording the insect food and protection, for within it the creature feeds in safety. In the same case they are also transformed: at the approach of the change the caterpillar lines the rolled leaf with silk, that the rough parts of it may not injure the chrysalis.

A great number of the smaller larva require an artificial covering, to protect them from the open air. Among these, some inhabit the interior parts of leaves, making their way between the superior and inferior membranes, living upon the parenchymous parts of the leaf: and as they are exceeding small, a leaf affords them a spacious habitation. If the distance between the membranes is not large enough for them, they enlarge the space by forming different folds in one of them, in which they can move with ease: from these circumstances they have been named by Mr. Reaumur miners of leaves. This illustrious author has described these larva, the flies into which they are changed, and all the various methods made use of by them in performing this work. Some mine a large oval or circular space; others form a kind of gallery, which are sometimes strait, sometimes crooked. They only leave a thin membrane on the upper side of the leaf; but they leave the under side more substantial. One species

species of moth which proceeds from these larva is very small, but exceedingly beautiful.

The larva of the phryganea mostly live in little cases of their own building, which are formed of a variety of materials, that they train after them in the water wherever they go. These cases are generally cylindrical, and open at both ends; the inside is lined with silk spun by the larva, the outside formed of different substances, as bits of reed, stone, gravel, and some entirely of small shells, &c. which they arrange and manage with singular dexterity. They never quit this case. When they walk they put out the head, and a few of the first rings of the body, training the case after them.

Having lived in the water for some time, they become inhabitants of the air. They assume the pupa form in the water, closing up the two ends of the case with bars of silk, by which it is secured from the attacks of its enemies; and at the same time there is a free passage for the water, which is still necessary for its existence; at a proper period the pupa forces its way through the case, and makes for the land, where its further change instantly commences, and is soon completed.

We shall close these specimens of the industry of insects with an account of that which is displayed by the larva of the tinea. The greatest part of the body of these little creatures, except the head and six fore feet, is covered over with a thin tender skin; the body of the insect is cylindrical, and lodged in a tube which is open at both ends. Soon after they are born they begin to cover themselves, and are, therefore, seldom to be found but in these tubes

tubes or cases. They are, in general, so small, that it is not easy to distinguish the cases without a magnifier; but as the body lengthens, the case becomes too short; it is, therefore, part of it's daily employ to lengthen the case. For this purpose, it extends the head beyond the tube, and having found the materials which answer it's purpose, it tears it off, and brings it to the end of the tube, and fixes it there, repeating this manœuvre till it has sufficiently lengthened it; after it has finished one end, it turns itself round within the case, and performs the same operation at the other.

This does not terminate their labours, for the tube must also be increased in diameter, as it soon becomes too small for the body; the means they make use of to enlarge it, is precisely the same as we ourselves should adopt under similar circumstances. The insect flits the tube at the two opposite sides, at the same end, and inserts in the slit two pieces of the required size; it then performs the same at the other end. By this means they soon enlarge it sufficiently, without exposing themselves to the air during the operation. The outside of these cases is made of silk, hair, &c. The inside is of silk only. Their covering always partakes of the colour of the cloth, or tree, &c. from whence it was taken. If it passes over a red piece, the colour will be red. When they are come to their perfect growth, they abandon the cloth, and seek for a proper place wherein they may pass from their present to a more perfect state.

I cannot conclude this long chapter better than in the words of Mr. Stillingfleet. "Many are apt to treat with contempt any man whom they see employed in poring over a moss, or examin-

ing an insect, from day to day, thinking that he spends his time and his life in unimportant and barren speculations; yet were the whole scene of nature laid open to our views, were we admitted to behold the connections and dependencies of every thing on every other, and to trace the œconomy of nature through the smaller as well as greater parts of this globe, we might, perhaps, be obliged to own we were mistaken; that the supreme architect had contrived his works in such a manner, that we cannot properly be said to be unconcerned in any one of them; and therefore, that studies, which seem upon a slight view to be quite useless, may in the end appear to be of no small importance to mankind. Nay, were we only to look back into the history of arts and sciences, we must be convinced that we are apt to judge over hastily of things of this nature. We should there find many proofs that he who gave this instinctive curiosity to some of his creatures, gave it for good and great purposes, and that he rewards with useful discoveries all these minute researches.

“ It is true this does not always happen to the searcher, or his contemporaries, nor even sometimes to the immediate succeeding generation; but I am apt to think, that advantages of one kind or other always accrue to mankind from such pursuits; some men are born to observe and record what perhaps by itself is perfectly useless, but yet of great importance to another who follows and goes a step farther, still as useless; to him another succeeds, and thus by degrees, till at last one of a superior genius comes, who laying all that has been done before this time together, brings on a new face of things, improves, adorns, exalts human society.

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“ All those speculations concerning lines and numbers, so ardently pursued, and so exquisitely conducted by the Grecians, what did they aim at? or what did they produce for ages? a little arithmetic, and the first elements of geometry, were all they had need of. This Plato asserts; and though, as being himself an able mathematician, and remarkably fond of these sciences, he recommends the study of them; yet he makes use of motives that have no relation to the common purposes of life.

“ When Kepler, from a blind and strong impulse, merely to find analogies in nature, discovered that famous one between the distance of the several planets from the sun, and the periods in which they complete their revolutions, of what importance was it to him or the world?

“ Again; when Galileo, pushed on by the same irresistible curiosity, found out the law by which bodies fall to the earth, did he, or could he, foresee that any good would come from his ingenious theorems? or was any immediate use made of them?

“ Yet had not the Greeks pushed their abstract speculations so far, had not Kepler and Galileo made the above-mentioned discoveries, we never could have seen the greatest work that ever came from the hands of man, Sir Isaac Newton's Principia.

“ Some obscure person, whose name is not so much as known, diverting himself idly, as a stander-by would have thought, with trying experiments on a seemingly contemptible piece of stone, found out a guide for mariners on the ocean, and such a guide as no science, however subtil and sublime it's speculations may be,

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however wonderful it's conclusions, would ever have arrived at. It was mere curiosity that put Sir Thomas Millington upon examining the minute parts of flowers; but his discoveries have produced the most perfect and most useful system of botany that the world has yet seen.

“ Other instances might be produced to prove, that bare curiosity in one age is the source of the greatest utility in another; and what has frequently been said of chymists, may be applied to every other kind of virtuosi. They hunt, perhaps, after chimeras and impossibilities; they find something really valuable by the-by. We are but instruments under the Supreme Director, and do not so much as know, in many cases, what is of most importance for us to search after; but we may be sure of one thing, viz. that if we study and follow nature, whatever paths we are led into, we shall at last arrive at something valuable to ourselves and others, but of what kind we must be content to remain ignorant.”



C H A P. VI.

GIVING SOME ACCOUNT OF THE ANATOMICAL STRUCTURE OF THE COSSUS, OR CATERPILLAR, WHICH IS FOUND IN THE TRUNK OF THE WILLOW; AND SEVERAL OTHER MISCELLANEOUS OBJECTS.

OF all the modifications of which matter is susceptible, the most noble is undoubtedly the organization thereof. In the structure of animals, the Sovereign Wisdom is exhibited to us in the most striking manner. The body of an animal is a little particular system, more or less complicated, and which, like the system of the universe at large, is the result of the combination and connection of a multitude of different pieces, which all conspire to produce one general effect, the manifestation of the principle which we term life. So wonderful are these combinations, that we are incapable of comprehending, or even of admiring sufficiently, the astonishing apparatus of springs, levers, counterweights, of tubes of different diameters, &c. which constitute these organical machines. The interior parts of the insect, the most vile in appearance, would absorb all the powers of the most able anatomist. He would be lost in the labyrinth as soon as he attempted to explore all its windings. A truth that will be evident

to every one who considers only the small portion of the anatomy of the caterpillar here exhibited, which is extracted from the wonderful work of Mr. Lyonet, entitled "*Traité Anatomique de la Chenille qui ronge le Bois de Saule,*" to which the reader must be referred for a more ample account of the structure of this animal; enough will be given here to convince every one of the power and use of microscopic glasses in the display of the wonders of creation; enough will be introduced to prove to the reader that it is not matters of magnitude which only engage the attention or art of the Almighty, "he delights to be elaborate on the minutenesses and minims of nature; to open his immensity, as it were, within a speck; to lavish his skill and ornaments on insects and butterflies; and to inform ants and bees with better sagacity and science than the most laboured systems of human policy can exhibit. For the littlenesses of our God are great beyond conception, and while the universe cannot contain him, his wisdom and might, his goodness and glory, and the fulness of his infinity, are entire, and displayed through every point of infinite space."²

Our theme no great (of ONE exclusive) knows;
No little when from ONE, that ONE it flows.

* * * * *

Where ONE, and only ONE, is truly GREAT!
All equidistant, or alike all near,
The reptile minim, or the rolling sphere;
Alike minutely great, or greatly less,
In form finite, INFINITY express;
Express the seal of CHARACTER DIVINE,
And bright, thro' HIS INFORMING RADIANCE SHINE.

We

* Brooke's Juliet Grenville, vol. 1, p. 198.

We shall first give a general description of the animal itself, and then proceed to explain those anatomical parts of it which are represented at Fig. 1, 2, 3, 4, 5, 6, 7, of Plate XII. This insect, like every other caterpillar, proceeds from an egg, which the parent moth takes care to deposit in general against the trunk of the willow; to this it is attached by a viscous humor, which soon becomes so hard that the rain cannot dissolve it.

The egg is very small, of an oblong spheroidal shape; when examined by the microscope, we find broad waving furrows running through the whole length of it, which are again crossed by close streaks, giving it the appearance of a wicker basket. It is probable that they are hatched some time in August, because the small caterpillars are often to be found in September. When small, they are generally to be met with under the bark of the tree to which the eggs were fixed; a humid oozing from the hole they have made to get under the bark, is often a direction where to search for them; though it is not always a certain sign, because the same effect is often occasioned by other insects.

These caterpillars change very little in their colour, being nearly the same when they are full grown as when they are very young. Like many others they are capable of spinning as soon as they are born. They change also several times their skin, but as it is almost impossible to raise them under a glass, it is not easy to determine how many times they moult or put off their skin; if we are to judge of the number of times by the difference in size between the new born and full grown caterpillar; and if we compare these with the increase of the head, every time it moults; we may reasonably conclude, that it changes
oftener

oftener than the generality of caterpillars, that is, more than four, five, or six times, for some have been observed to moult above nine times.

We have already taken notice of these changes in the last chapter. The caterpillar generally fasts for some days previous to the moulting, the fleshy and other interior parts of the head are then detached from the old skull, and retire as it were within the neck; it is soon however cloathed with pieces similar to those it has abandoned, only larger and at first very soft. When the new skin and the other parts are formed, the old skin is to be opened, and all the members withdrawn from it, an operation naturally difficult, but which must be rendered more so from the soft and weak state of the little creature at that time. The caterpillar is always much larger after the change.

It appears from the experiments of M. Lyonet, that this caterpillar generally passes two winters at least, if not three, before it assumes the pupa state, but then it neither acts nor eats in the winter, forming at the approach of this season a little case or habitation, the inside of which is lined with silk, and the outside covered with small pieces of wood like fine saw-dust: inclosed in this it waits the return of spring. They are sometimes three inches and an half long when full grown, the smallest about two inches. The size which they attain is very great, if compared with that of the new born caterpillar, which does not exceed one twelfth of an inch, an increase in growth much superior to that of the larger animals.

It generally prepares for the pupa state in the month of May; it's first care being to find a hole in the tree sufficient to give issue to the moth: and if it finds none proper for the purpose, it makes one equal in size to the future pupa. The hole being made or found, it begins to construct a case or cone, which it forms of thin pieces of wood, uniting them together, by silk, into an ellipsoid-shape; the outside is formed of little sticks united together in all directions; the caterpillar takes care that the pointed end of the case may be always opposite to the mouth of the hole: having finished the outside of the case, it lines the inside with a silken tapestry, of a close texture in all parts, except the pointed end, and where the tissue is looser, in order to facilitate it's escape at a proper season. The work being finished, the caterpillar places itself in the case in such a manner, that it's head may always lay towards the opening of the hole in the tree or pointed end of it's case.

In this state it remains at rest for some time; the colour of the skin first becomes pale, afterwards the whole skin appears brown. The interior parts of the head are detached from the skull, the legs retire or withdraw themselves from their exterior case, the body shortens, the posterior part grows small, while the anterior part swells so much, as at last to burst the skin, which, by a variety of motions, it pushes down to the tail, and thus exhibits the pupa, in which the parts of the future moth may be easily traced.

The covering of the pupa is at first soft, humid, and white, but it soon dries and hardens, and is then of a marron colour; the fore-part, in which the lineaments of the head, the legs, and

the wings of the moth may be discovered, is quite immoveable, but the posterior part is moveable. The anterior end of this pupa is furnished with two horns, one above the other, under the eyes; there are also on it's back several rows of points one under the other, the points directed towards the tail. The pupa remains in it's case for some weeks; as soon as the moth that is formed therein finds itself enabled to break the bonds by which it is confined, it begins to agitate itself within the case; the points are then rendered of essential service, those on the back serve as a fulcrum, to prevent it's slipping backwards, while it is opening the hole of the cone with those on the head.

The new-formed moth labours in general about a quarter of an hour before it can effectually open the case. This being done, by redoubled efforts it enlarges the hole, and presses itself forwards, till it arrives at the edge, where it makes a sudden stop; for if it advanced further it would fall to the ground, and probably lose it's life, or be materially injured by the fall. Here then the pupa repofes itself for a time, after which the moth begins to disengage itself from the bonds which confine it; when it has escaped from the pupa, it fixes itself against the trunk of the tree, with the head upwards, and often remains in this situation for some hours, during which time the wings and members are perfectly developed, and rendered fit for action. I have been informed by Mr. Marfham, that it generally pushes at least one-third of the case out of the hole before it halts.

DESCRIP-

DESCRIPTION OF PLATE XII.

The body of the caterpillar in this plate is divided into twelve parts, corresponding to it's rings. These divisions are marked in Fig. 2 and 3, Plate XII. by the numbers 1, 2, 3, up to 12; to the first number the word RING is annexed.

Each of these rings is distinguished from that which follows, and that which precedes it, by a kind of neck or small hollow part. By conceiving a line to pass through these necks, and forming boundaries to the rings, we acquire twelve more divisions; these are also marked 1, 2, 3, 4, &c. to 12, but to the first the word DIVISION is affixed.

To facilitate further the description of this animal, M. Lyonet found it necessary to form some ideal divisions, or rather lines, to pass through it. He therefore supposed, first, a line to pass down the middle of the back, and this he called the superior line, because it marked the most elevated part of the back of the caterpillar; the inferior line, one directly opposite to the former, and passing from the head down the belly to the tail.

In all caterpillars, on the right and left of each ring, except the second, third, and last, there is a little organ, something to appearance like an elliptic spot; these are termed the spiracula, and have been mentioned several times in this work; as they are situated nearly at equal distances from the superior and inferior lines, they furnish us with a further sub-division, called the lateral lines, which pass through the spiracula, the one on the right, the other on the left side of the caterpillar.

S s

These

These four lines, which we may conceive to divide the caterpillar longitudinally into four equal parts, are attended with this remarkable circumstance, that each of them mark the place under the skin that is occupied by a considerable viscera; the heart, or rather the thread of hearts, lies under the superior line; the spinal marrow immediately over the inferior line; the two tracheal arteries follow the course of the lateral lines.

At equal distances from the superior and two lateral lines, and the inferior lines, we may suppose four intermediate lines. The two between the superior and lateral lines are called intermediate superior lines; the two others which are opposite to them, and between the lateral and inferior lines, the intermediate inferior lines.

AN EXPLANATION OF FIGURES 1 AND 2, PLATE XII; OR AN ACCOUNT OF THE MUSCLES OF THE CATERPILLAR WHEN OPENED BY THE BELLY.

Of all the interior parts of the caterpillar, none present so beautiful a view, or a more wonderful and symmetrical arrangement, than that of the muscles; the more so, if they are taken away by equal strata on both sides, so as to expose at the same time the similar muscles on the opposite side, and by this means exhibit to the astonished eye their exact form and correspondence.

Fig. 1 and 2 is a representation of the muscles of two different caterpillars, opened at the belly, and supposed to be joined together at the superior lines; for as the muscles on the opposite

side of each caterpillar are perfectly similar, it was not only unnecessary to represent them, but by joining another view of the muscles, as in Fig. 2, we are enabled to exhibit those muscles which were covered in Fig. 1, and by this means save much time in the description, and the addition of another plate.

The dorsal muscles, or those of the back, are marked by capital letters; the gastric muscles, or those of the belly, by Roman letters; the lateral muscles by Greek characters. Mr. Lyonet has only given a name to those among the latter, which are marked θ ; these are placed upon all the divisions, from the second to the eleventh; they are called dividing muscles, on account of their situation; a muscle that has been once marked with a letter always retains the same, both in the description and the other figures.

PREPARATION.

The caterpillar was emptied, and the muscles freed from the masses of fat, the nerves, and other vessels, which, if they had been left, would have confused the view of the muscles, and rendered it difficult to distinguish and trace them.

FIRST RING.

The muscle A is double. The anterior one is thick at top, and seems to be divided into different muscles on the upper side, but it has no such appearance on the under side. One of their insertions is towards the head, at the skin of the neck; the other insertion of the first muscle A is a little above, and that of the

second muscle A is a little below the first spiraculum, near which they are fixed to the skin.

α is long and slender; it is fixed by it's anterior extremity under the gastric muscles (a and b) of the first ring, to the circumflex scale of the base of the lower lip. After having passed under some of the arteries, it introduces itself under the muscle θ , and communicates there with the muscle c of the second ring.

β is sometimes single, sometimes double, and sometimes triple; it is hardly possible to open the caterpillar by the belly without breaking it; the anterior fixture is to the posterior edge of the side of the parietal scale; the lower fixture is at the middle of the ring, near the inferior line,

The muscles marked ζ are three in number; the first is fixed at one extremity. near the lower edge of the upper part of the parietal scale; the other end divides itself into three or four tails, which are fixed to the skin of the caterpillar under the muscle δ .

The anterior end of the second has it's insertion near the former; that of the third a little under the two foregoing, at the skin of the neck, under the muscle A. These two last passing over the cavity of the first pair of limbs, are fixed by several tails to the edge opposite to this cavity.

In this subject there are two muscles marked δ , sometimes there is only one; their anterior fixture is to the lower edge of the parietal scale; the other ends are inserted in the first fold of the skin of the neck, on the belly side.

β and

β and δ are best seen in Fig. 3, where they are entire, not being injured by an unnatural extension.

OF THE SECOND AND FOLLOWING RINGS, TO THE LAST.

Two large dorsal muscles, A and B, are discovered in the second and four following rings. There are three, A, B, C, in the 7th, 8th, 9th, and 10th rings; four, A, B, C, D, are to be seen at the 11th ring; and five, A, B, C, D, E, at the anterior part of the 12th ring.

All these files, or ranges of muscles, A, B, C, and E, as well as the gastric muscles, a, b, c, d, appear at first sight only as a single muscle, running nearly the whole length of the caterpillar; but when this is detached from the animal, it is found to consist of so many distinct muscles, each muscle only the length of one of the rings; their extremities are fixed to the divisions of each ring, excepting the muscle a, which at the 6th, 7th, 8th, and 9th rings has its insertions rather beyond the divisions. Each row of muscles appears as one, because they are closely connected at top by some of the fibres, which pass from one ring to the other. The muscles A, B, C, E, from their situation may be called the right muscles of the back; and for the same reason the muscles a, b, c, and d, may be called the right muscles of the belly.

From the third ring the muscles A, which are twelve in number, gradually diminish in breadth to the lower part of the last ring; at the 8th and three following divisions they communicate with the muscles B, and at the 11th with D. In the lower part
of

of the last ring, A is much broader than it was in the preceding ring; one extremity of it is contracted, and communicates with B; the lower infertion is at the membrane I, which is the exterior skin of the fecal bag.

It may be proper to observe, that the muscles, A and B, of the lower part of the last ring, cannot be seen until a large muscle is removed, which on one side is fixed to the subdivision of this ring, on the other to the fecal bag.

The right muscles B are also twelve in number; they begin at the second ring, and grow larger from thence to the 7th: from the 7th to the subdivision of the 12th they are one-half narrower; the deficiency in width is supplied by the six muscles C, which go with it from the 7th to the subdivisions of the 12th ring. The muscles B and C have a lateral communication at the 8th, 11th, and 12th divisions; C is wanting at the subdivision of the 12th ring; its place is filled up by B, which becomes broader in that part.

We have now only to speak of the three floating muscles V. The first of these originates at the first ring, from whence it introduces itself under N, where it is fixed, and then subdivides, and passes under parts which render it invifible in this figure.

The second floating muscle begins at the second division, being fixed to the anterior extremity B of the second ring; from thence it directs itself towards the stomach, and after communicating with the caecum of the corpus crassum, it divides and spreads itself into eight muscles, which run along the belly.

The

The third, V, begins at the third division, originating partly at the skin, partly at the junction of the muscles B of the second and third ring. It directs itself obliquely towards the belly, meeting it near the third spiraculum; branching from thence, it forms the oblique muscles of this viscera.

The thin long muscle \emptyset , which is at the subdivision of the last ring, and covers the anterior insertion of the large muscle (a), where the ring terminates, (*il est sans paire*) it is single; it begins at one extremity of the muscle c, at the fore part of the ring, runs along the subdivision, round the belly of the caterpillar, and finishes on the other side, at the extremity of a similar muscle C.

EXPLANATION OF FIG. 2, PLATE XII.

PREPARATION.

All the dorsal muscles, thirty-five in number, were taken out, as well as the seven lateral ones which have been described in the preceding figure.

All the stria muscles of the belly were also taken away, as well as the muscular roots c, and the ends of the gastric muscles c, which are at the third and fourth division.

At the second division the middle of the muscle \emptyset was removed, the extremities only being left to point out where it was inserted.

The

The tracheal artery was also removed.

EXPLANATION OF THE FIRST RING.

We see fully here the muscles C * ζ and (i) which were but partly seen in the preceding figure, and the gastric muscles g, which were not seen there.

The muscles C * occupy two rings; it is very difficult to determine their precise number; ten may be counted at the anterior end, which are collected in one fascicle, and inserted at the side of the upper part of the parietal scale, immediately under the muscles ζ; towards the lower end these muscles spread like a fan, and a greater number may be counted; they communicate laterally with each other by reciprocal branches, which makes it difficult to determine whether they should be considered as single muscles, or as so many distinct ones. The lower extremity of all but the two last cross, at the superior line of the second ring, the tails of similar muscles on the opposite side; after which, they are inserted at the skin beyond this line.

There are five lateral muscles ζ, sometimes six; they have their first fixture at the side of the head, their lower part widens, and is inserted lengthways in the second division.

The muscles θ of the first ring, as well as the similar muscles of the nine other rings, are better seen in this than in Fig. 1; as they are placed over the divisions, they may be termed dividing muscles. That of the second division has been separated to shew the muscles underneath. It is single as well as that of the third division

division; that of the fourth is double; they appear more numerous in the succeeding divisions, though they are, in general, only double, seldom triple, but much thicker; those of the third and fourth division pass over the tracheal artery, whilst all the others go under it: we find them at all the divisions but the first and last.

SECOND RING.

The dorsal muscles are sufficiently seen in this ring, to enable the observer to form some idea concerning them.

C is the only one which is fairly exposed; it has its posterior insertion at the third division, near the intermediate superior line, from whence advancing obliquely it becomes forked, one branch passes under the dividing muscle, and is fixed to the skin, from whence it again proceeds, and forms the fine long muscle α of the first ring. The other branch is fixed to the skin, near the lateral line, under the muscle γ of the second ring.

When the muscle C and some of the muscles C* are removed, we see the whole of D; the direction of this muscle is entirely contrary to that of C.

After taking away D, we discover the muscle E, which is inclined towards the same side as C, but not so obliquely. By taking away E we are enabled to see the muscle F, which is parallel to D: these three last muscles are fixed to the divisions which terminate the rings; the lateral muscles are not seen so as to be described.

T t

THE

THE THIRD RING

Presents four dorsal muscles, C, D, E, F. The first dorsal muscle, C, is inserted at the third division under the muscles β and α , where it communicates, by means of some fibres, with the muscle f of the second ring; from thence it proceeds obliquely towards the intermediate superior line, and is fixed at the fourth division.

As soon as C is retrenched, the muscle D is seen; this grows wider from the anterior extremity; it lies in a contrary direction to the muscle C, and is inserted into the third and fourth divisions.

The muscle E lies in the same direction as the muscle C, but not so obliquely; the lower insertion is at the fourth division, the other is at the third, immediately under C.

The muscle F is nearly parallel to D, which joins to it; the first insertion is visible, the other is at the fourth division, under the muscles E and G.

There are no lateral muscles to be described in this ring.

THE EIGHT FOLLOWING RINGS.

There are only two dorsal muscles, and no lateral ones, to be described in these rings.

Of these two muscles, D is the only one that is altogether seen; it is very large, and diminishes gradually in breadth, from ring to ring, to the left, branching off in some places.

E is one of the strait muscles of the back, and is inserted at the divisions of it's own ring, under the dividing muscles θ .

ANTERIOR PART OF THE TWELFTH RING.

There are three dorsal muscles, D, E, F, to be considered in this part.

The muscle D is similar to D of the preceding ring, only that it terminates at the subdivision of it's ring, and is consequently only half as long.

E is of the same length, and differs from the muscle E of the preceding ring only in it's direction.

The muscle F is parallel to E, and shorter; it's anterior end does not reach the twelfth division.

POSTERIOR PART.

There is only one dorsal muscle here, which is fastened by some short muscles to the subdivisions of the last ring, traversing the muscles α , and being fixed there, as if designed to strengthen them, and to vary their direction.

α is a single muscle; its anterior insertion is visible, the other end is fixed to the bottom of the foot of the last leg; it is used to move the foot.

The anterior part of the muscle β is divided into three or four heads, which cross the superior line obliquely, and are fixed to the skin a little above it. The other end is fastened to the membrane T.

AN EXPLANATION OF FIGURES 3 AND 4, OF PLATE XII.
OR AN ACCOUNT OF THE MUSCLES OF THIS CATERPILLAR
WHEN IT IS OPENED AT THE BACK.

PREPARATION FOR FIG. 3.

The muscles were not only disengaged from all extraneous matter, as before, but as it represents the third figure of Mr. Lyonet, on the muscles of the caterpillar's back a great many had been removed before the parts of the insect appeared, as delineated in this figure.

FIRST RING.

Only two gastric muscles, c d, are seen here; c is broad, and has three or four little tails; the first fixture is at the base of the lower lip, from whence it descends obliquely, and is fixed between the inferior and lateral line,

The

The little muscle *d* is fastened on one side to the first spiraculum, and on the other side, a little lower to the intermediate inferior and the lateral line; it seems to be the antagonist of *P*, which opens the spiracula.

The lateral muscles β δ are very well seen in this figure; the posterior fixture of δ is under the muscle *C*; near the skin of the neck; β is fixed a little on the other side of *C*, at the middle of the ring.

SECOND RING.

Three gastric muscles, *g*, *h*, *i*, appear here; *g* and *h* are fixed at the folds which terminate the ring; *i* has only it's anterior fixture there.

h is triple; in one of the divisions it is separated into two parts.

i approaches more the inferior line, and is fixed a little beyond the middle of the ring, where the similar muscle on the opposite side is forked to receive it.

THIRD RING.

h, which was triple in the preceding ring, is double here; that part which is nearest the inferior line is the broadest; it has three tails, of which only two are visible.

The

The muscle *i* is exactly similar to that of the preceding ring, and is crossed in the same manner by the muscle from the opposite side of the ring.

THE EIGHT FOLLOWING RINGS.

The muscle *f*, in all these rings, is very broad and strong; the anterior fixture is at the intermediate inferior line, on the fold of the first division of the ring; the other fixture is beyond the lower division, with this difference, that at the 10th and 11th rings the fixture is at the last fold of its ring; whereas in the others it passes over, and is inserted in the skin of the following ring.

In all these rings the first extremity of *g* is fastened to the fold which separates the ring from the preceding one, and is parallel to *f*, and placed at the side of it.

The six first, *g*, are forked; that of the fourth ring is very much so; it does not unite till it is near its anterior insertion. The longest tail lays hold of the following, and is inserted near the inferior line; the other inserts itself near the same line, at about the middle of its own ring.

The two last, *g*, do not branch out, but terminate at the divisions without reaching the following ring.

The muscle *h* is placed at the side of *f*, has nearly the same direction, and finishes at the folds of the ring.

ANTE-

ANTERIOR PART OF THE TWELFTH RING.

The only gastric muscle left here is *e*; it is placed on the intermediate inferior line; in it's direction it separates from it's lateral, and is inserted at the folds of the upper division, and at the subdivision of this ring.

LOWER PART OF THE TWELFTH RING.

e is a large muscle, with several divisions; one placed under (*b*) of the preceding figure, one extremity is fixed near the lateral line, at the subdivision of it's ring, the other to the fecal bag, a little lower than the muscle *b*.

EXPLANATION OF FIG. 4, PLATE XII.

All the gastric muscles described in the preceding figure disappear in this, as well as all those lateral and dorsal ones whose letters are not found in this figure.

FIRST RING.

e f g are the gastric muscles, which are best seen here.

e is narrow and long; it passes under and crosses *f*, one of it's insertions is at the lower line, the other is at the lateral, between the spiraculum and the neck.

f is

f is short, broad, and nearly straight, placed along the intermediate line, but between it and the lateral; it passes under e, and is fixed to the fold of the skin which goes from one leg to the other; the lower insertion is near the second division.

There are sometimes three muscles g, and sometimes four; their lower fixture is about the middle of the ring; the anterior insertion is at the fold of the skin, near the neck.

The muscles i and h are also fixed to the same fold; the other end of h is fixed under the muscle II, near the spiraculum.

Above the upper end of f, a muscular packet g, formed by the separation of two floating muscles, may be seen; though only imperfectly, as they were injured by the dissection.

SECOND RING.

Six gastric muscles, k, l, m, n, o, p, may be pretty well distinguished in this ring.

k is a large oblique muscle, with three or four divisions, placed at the anterior part of it's ring; the head of it is fixed between the inferior line and it's intermediate one, at the fold of the second division, from whence it crosses the inferior line, and it's similar muscle; it terminates to the right and left of this line.

l is a narrow muscle, whose head is fixed to the fold of the second division, the tail of it lies under n, and is fastened to the edge of the skin that forms the cavity for the leg.

m, two muscles of the same obliquity, placed one on the other; the head of it is inserted in the skin, under the muscle β , and communicates, by a bed of fibres, with the tail of the muscle γ ; the other end is fixed to the intermediate inferior line, at the fold of the third division.

n is large and broad; it covers the lower edge of the cavity of the limb, and the extremity of the tail of l; the first fixture is at the skin, near the intermediate line, from whence it goes in a perpendicular direction towards m, and introduces itself under o and m, where it is fixed.

o is narrow and bent, and covers a little the edge of the cavity of the leg; one end terminating there, the other end finishes at the third division near m.

p is also bent; it runs near the anterior edge of the cavity of the leg; one end meets the head of o, the other end terminates at a raised fold, near the inferior line.

On the side of the lateral muscle o there is a triangular muscle, similar to q of the following ring; it is entirely concealed in this by the muscle m.

THIRD RING.

This ring has no muscle, similar to m of the preceding ring.

U u

k only

k only differs from the muscle of the second ring, in that it is crossed by the opposite muscle, whereas k crosses the opposite muscle.

As the muscles l, n, o, p, of this ring are similar to those of the preceding one, they need not be described.

q is a triangular muscle; the base of it is fastened to the last fold of it's ring, on the lower side it is fixed to the muscle o, the summit to the skin at the edge of the cavity for the leg.

THE EIGHT FOLLOWING RINGS.

We discover here the gastric muscles, i, k, l, m.

The muscle i is quite strait, and is placed at a little distance from the inferior line; it is broad at the fourth ring, but diminishes gradually in breadth to the eleventh. It is united at the fourth, but is divided into two heads, which divaricate in the following rings. In the six next rings these heads are fixed nearly at the same place with a and f; in the other two it terminates at the fold of the ring. The anterior insertion of the first and last is at the fold, where the ring begins; that of the six others is somewhat lower, under the place where the muscle i, which precedes them, finishes.

k is an oblique muscle, whose lower insertion is at the skin near i; the other at the intermediate inferior, upon the fold which separates the following ring; it is missing in the eleventh ring.

l is

I is a large muscle which co-operates with M; in opening and shutting the spiraculum, one of it's fixtures is near the intermediate inferior line, at about the same height as i; the tail finishes a little lower than the spiraculum.

TWELFTH RING.

There remains here only the gastric muscle d, which is a fascicle of six, seven, or eight muscles; the first fixture of these is at the subdivision of the ring, near the inferior line; one or two cross this, and at the same time the similar muscles of the opposite side. Their fixture is at the bottom of the foot; their function is to concur with the muscle α , in bringing back the foot, and loosen the claw from what it lays hold of.

We perceive here the muscle α ; one of it's insertions is at the bottom of the foot, near d; the other extremity near the subdivision of the ring.

EXPLANATION OF FIG. 5 AND 6, PLATE XII.

The anatomical delineation of the head, which is given at Fig. 5 and 6, should be considered as consisting of two figures, which join in the middle, being terminated by the inferior and superior lines. It will be impossible in this place to give more than a very loose idea of the head of the caterpillar in these two figures, as M. Lyonet found it necessary to employ twenty, in order to display properly the organization of this part. These will, however, be sufficient to give some idea of it to those who cannot procure or read the work itself; it may also serve to stimulate those who

have leifure to extend further the anatomy of insects; for it is only by a comparifon of their's with that of man, that we can ever afcertain their true place in the fcale of creation. If this comparifon could be accurately difcovered, the true philofopher would be able to trace their final caufe, or rather the originating fource of their exiftence, and point out the degree in which they accorded with thofe laws of goodnefs and truth, by which the univerfe and all it's parts are regulated and governed.

The head, as represented in thefe figures, is magnified about three hundred and forty-three times; it is feparated from the neck, and difengaged from the fat. The figures here under confideration represent the head in the third and fourth ftate of examination, when a great many parts had been removed, in order to difcover thofe that are here feen.

HH, the two palpi. The truncated mufcles D belong to the lower lip, and form a part of it's moving mufcles. K is the two ganglions of the neck united. II, the two filk veffels. L, the oefophagus. M, the two diffolving veffels.

N 1, 2, 7 are the continuation of four cephalic arteries. Fig. 5, S S, T T, V V, and Z, are the ten abductor mufcles of the jaw. Fig. 6, under e e and f f, are feen four occipital mufcles. a k, a nerve of the firft pair belonging to the ganglion of the neck; b, a branch of this nerve.

Fig.

FIG. 7, PLATE XII.

Is an outline of the head, magnified considerably more than in the last figures, exhibiting the nerves as seen from the under part.

Excepting in two or three nerves (and these may be easily known, because each nerve of the same pair is marked with a similar letter), only one nerve of each pair is drawn, as a greater number would have occasioned much confusion.

The nerves of the first ganglion of the neck are designed by capital letters.

The nerves of the ganglion a of the head are distinguished by Roman letters.

The nerves of the small ganglion by Greek characters.

Those of the frontal ganglion, except one, by numbers.

A GENERAL IDEA OF THE INTERIOR PARTS OF THE
CATERPILLAR.

Having described so many of the parts as to evince the amazing wonders that are displayed in this insect, I proceed to give a more particular account of the nature of some of those parts.

OF

OF THE DIFFERENT ORDERS OF MUSCLES, BY WHICH THE
CATERPILLAR IS ENABLED TO MOVE ALL THE VARIOUS
PARTS OF THE BODY.

These muscles have neither the exterior form, nor the colour of those of larger animals. In their natural state they are soft, and have the appearance of a jelly; they are of a greyish blue, and the silver-coloured appearance of the aerial or pulmonary vessels, which creep over and penetrate their substance, exhibits under the microscope a most beautiful spectacle. When the caterpillar has been soaked for some time in spirit of wine, they lose their elasticity and transparency, and become firm, opaque, and white; the aerial vessels disappear. At first sight they might be taken for tendons, as they are of the same colour, and possess almost the same lustre. They are generally flat, and of an equal size throughout; the middle seldom differs either in colour, substance, or size, from the extremities.

The ends are fixed to the skin; the rest of the muscle is generally free and floating; several of them branch out considerably; the branches extend sometimes so far, that it is not always easy to discover whether they are distinct and separate muscles, or parts of another. They are of a moderate strength; those that have been soaked in spirit of wine, when examined by the microscope, will be found to be covered with a membrane, which may be separated from them; they then appear to consist of several parallel bands, directed according to the length of the muscle. These, when divided by the assistance of very fine needles, appear to be composed of still smaller fascicles of fibres, in the same direction, which, when examined with a very deep magnifier,

magnifier, and in a favourable light, appear twisted like a small cord. The muscular fibres of the spider, which are much larger than those of the caterpillar, are found on examination to consist of two substances, one soft, and the other hard; the last is twisted round the former spirally, and thus gives to it the afore-mentioned cord-like appearance.

If the muscles are separated by means of very fine needles, in a drop of some fluid, we find that they are not only composed of fibres, membranes, and aerial vessels, but also of nerves; and from the drops of oil that may be seen floating on the fluid, that they are also furnished with many unctuous particles.

The number of muscles in a caterpillar is very great, exceeding by much those of the human body; the reader may form some idea of their quantity, by looking at Fig. 1 and 2, 3 and 4, of Plate XII. They occupy the greatest part of the head; there is an astonishing number at the oesophagus, the intestines, &c. the skin is as it were lined by different beds of them, placed one under the other, and ranged with very great symmetry.

The number of muscles that our observer has been able to distinguish is truly astonishing; he found 228 in the head, 1647 in the body, 2066 in the intestinal tube, making in all 4041.

THE SPINAL MARROW, and the brain of the caterpillar, if they can be said to have any, seems to have very little relation to those of man; in the last, the brain is inclosed in a bony cavity; it occupies the greatest part of the head, and is anfractuous, and divided into lobes. There is nothing similar to this in the caterpillar;

pillar; we find indeed in the head of that which we are describing, a part which seems to answer the purpose of the brain, because the nerves that are disseminated through the head are derived from it; but then this part is unprotected, and so small, that it does not occupy one-fifth part of the head; the surface is smooth, and has neither lobes nor any anfractuosity: and if we must call this a brain, the caterpillar may be said to have thirteen, as there are twelve more such parts following each other in a line; they are nearly of the same size with that in the head, and of the same substance, and it is from them that the nerves are distributed through the whole body. Lest the idea of thirteen brains might be disagreeable to his readers, M. Lyonet has called these parts ganglions.

The spinal marrow in the human species descends down the back, inclosed in a bony case; is large with respect to it's length, and not divided into branches, diminishing in thickness in proportion as it is removed further from the brain. In the caterpillar, the spinal marrow goes along the belly, is not inclosed in any tube, is very small, forks out at intervals, and is nearly of the same thickness throughout, except at the ganglions. For a description of the innumerable vessels, and curious texture of these parts, we must refer the reader to M. Lyonet's work. The substance of the spinal marrow, and of the ganglions, is not near so tender and easily separated as in man; it has a very great degree of tenacity, and does not break without considerable tension. The substance of the ganglions differs from that of the spinal marrow, as no vessels can be discovered in the latter, whereas the former are full of very delicate ones. The patient anatomist of the caterpillar has counted forty-five pair of nerves, and two single ones;

ones; so that there are ninety-four principal nerves, whose ramifications are innumerable.

The TRACHEAL ARTERIES of the caterpillar are two large aerial vessels that creep under the skin, close to the spiracula, one at the right side of the insect, the other at the left, each of them communicating with the air, by means of nine spiracula; they are nearly as long as the body, beginning at the first spiraculum, and going a little farther than the last, terminating in some branches, which extend to the extremities of the body.

Round about each spiraculum the tracheal artery pushes forth a great number of branches, which are again divided into smaller ones, which further subdivide, and spread through the whole body of the caterpillar.

The tracheal artery, and its numerous ramifications, are all open elastic vessels, which may be pressed close together, or drawn out considerably, but return immediately to their usual size when the tension ceases. They are naturally of a silver colour, and have a very beautiful appearance in the microscope.

This vessel and its principal branches are composed of three coats, which may be separated one from the other. The exterior covering is a thick membrane, furnished with a great number of fibres, which describe a vast variety of circles round it, communicating with each other by numerous shoots.

The second is very thin and transparent; no particular vessel is distinguished in it. The third is composed of scaly threads,
W w which

which are generally turned in a spiral form, and come so near each other as scarce to leave any interval; these threads are curiously united with the membrane which occupies the intervals, and form a tube which is always open, notwithstanding the flexure of the vessel. There are also many other peculiarities in it's structure, which cannot be well explained without more plates.

The principal tracheal vessels branch out into 236 smaller ones, from which there spring 1326 different ramifications.

The part of the caterpillar which naturalists call the heart, without being certain that it performs the functions thereof, is of a nature very different from that of larger animals. It is almost as long as the caterpillar itself, lies immediately under the skin at the top of the back, entering into the head, and terminating near the mouth. It is large and spacious towards the last rings of the body, and diminishes very much as it approaches the head, from the fourth to the twelfth division; it has on both sides, at each division, an appendage, which partly covers the muscles of the back; but growing narrower as it approaches the lateral line, forms a number of irregular lozenge-shaped bodies.

This muscular tube has been called the heart of the caterpillar; first, because it is generally filled with a kind of lymph, which has been supposed to be the blood of the caterpillar; secondly, because in all caterpillars, whose skin is in some degree transparent, continual, regular, and alternate dilations and contractions may be perceived along the superior line, beginning at the eleventh ring, and going on from ring to ring to the fourth, whence this vessel has been considered as a file of hearts; but
still

Still this viscera seems to have very little relation to the heart of larger animals; we find no vessel opening into it, to answer to the aorta, or vena cava, &c. &c.

Near the eighth division are two white oblong masses, that join the tube of the heart; they have been called reniform bodies, because they are something similar to a kidney in their shape.

The corpus crassum is, with respect to volume, the most considerable part of the whole caterpillar; it is the first and only substance that is seen on opening it, forming a kind of sheath, which envelopes and covers all the entrails, and introducing itself into the head, enters all the muscles of the body, filling the greatest part of the empty spaces in the caterpillar. It is of a milk-white colour. In its configuration it is very similar to the human brain.

When the different masses of the corpus crassum which covers the entrails are removed, the largest parts are the oesophagus, the ventricle, and the large intestines.

The oesophagus descends from the bottom of the mouth to about the fourth division. The anterior part which is in the head is fleshy, narrow, and fixed by different muscles to the crustaceous parts thereof; the lower part, which passes into the body, is wider, and forms a kind of membranaceous bag, which is covered with very small muscles; near the stomach it is again narrower, and is as it were bridled by a strong nerve, which is fixed to it at distant intervals.

The ventricle begins a little above the fourth division, where the oesophagus finishes, and terminates at the tenth division; it is about seven times longer than it is broad; the anterior part, which is the broadest, is generally folded.

The folds diminish with the bulk, in proportion as it approaches the intestines. A great quantity of nerves cover the surface, it is surrounded by a number of aerial vessels, and opens into a tube, which M. Lyonet calls the large intestine. There are three of these large tubes, each of which differs from the others so much, both in structure and character, as to require a particular name to distinguish them; though this is not the place to enumerate these characteristic differences.

As most caterpillars are endowed with a power, or faculty, of spinning, they are provided with two vessels where the substance is prepared, which, when drawn out, and extended in the air, becomes a filken thread; these two vessels are termed the silk vessels, or tubes; in the cossus they are often above three inches long, and are distinguished into three parts, the anterior, the intermediate, and posterior. The cossus has also two other vessels, which are supposed to prepare and contain the liquor by which it dissolves the wood on which it feeds. Thus have we endeavoured to give the reader an idea of the wonderful organization of this apparently imperfect animal. Assuredly, the 4000 * muscles employed in the construction of the cossus cannot be considered without the deepest astonishment! their admirable co-ordination and junction with other parts equally numerous, yet all

* Lyonet sur la chenille de faule, p. 584.

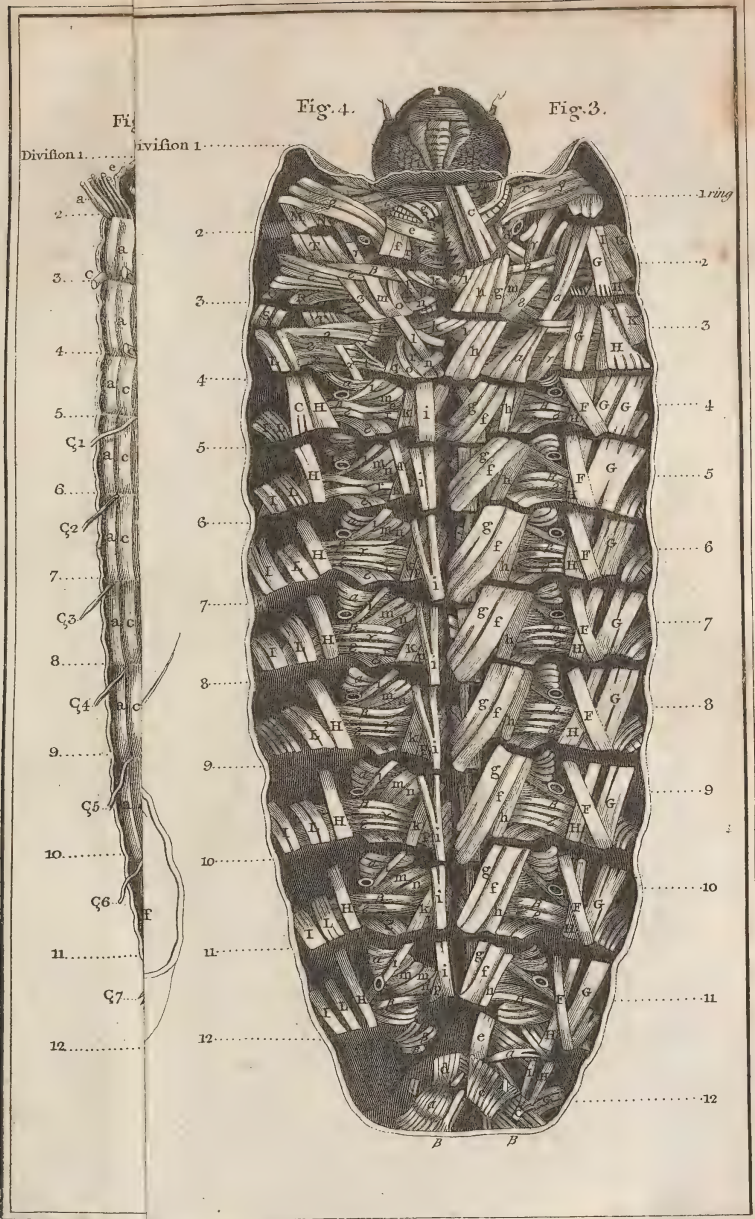
all harmonizing and acting together as if they were essentially one, naturally lead the mind to consider the nature and perfection of the theatre of creation ; and to perceive that it is an exhibition of the highest wisdom, and that this wisdom, which in the minutest things gives evidence of such an immense attention to order and use, has, no doubt, framed the whole for some great purpose ; but what that purpose is, we shall find it difficult to discover.

Though there is no doubt that even this difficulty may be removed, when mankind begin to consider the universe as one connected whole, manifesting and representing the action of an all-beneficent Creator on his creatures, according to the several degrees in which they are capable of receiving and displaying this action ; or, in other words, that this transitory scene is the ultimate result of the state of purity, or error of those intelligences which act thereon. But it would lead us too far from the subject in hand, to enter into a discussion of this truly interesting subject. We must, therefore, content ourselves with recommending the reader to study nature ; with the scriptures in his hand, he may be assured that he will not only find that they perfectly agree with each other ; but he will also find, upon an attentive comparison of passages of scripture with each other, that those parts which he may have hitherto only considered as pleasing figures, descriptive imagery, and perhaps as the sublime and beautiful of eloquence, have a more distinct and close connection with the sublime and beautiful of nature ; that they point out the natural, anatomical, and physical relation of the various parts of animated nature with man, and of man with superior intelligences.

He would find that this knowledge was not founded upon the testimony of a few obscure passages, but that every word of the sacred writings, when properly compared with others, will evince that they proceeded from the infinite source of wisdom, and contain such treasures from that fountain, as surpass the utmost effort of human ability to fathom; and yet that enough is laid open to satisfy every real inquirer after truth.

The following character of Mr. Lyonet's work, by M. Bonnet, cannot, I think, but prove agreeable to the reader. I give it in the original, as I am persuaded it would lose much of its genuine force by a translation.

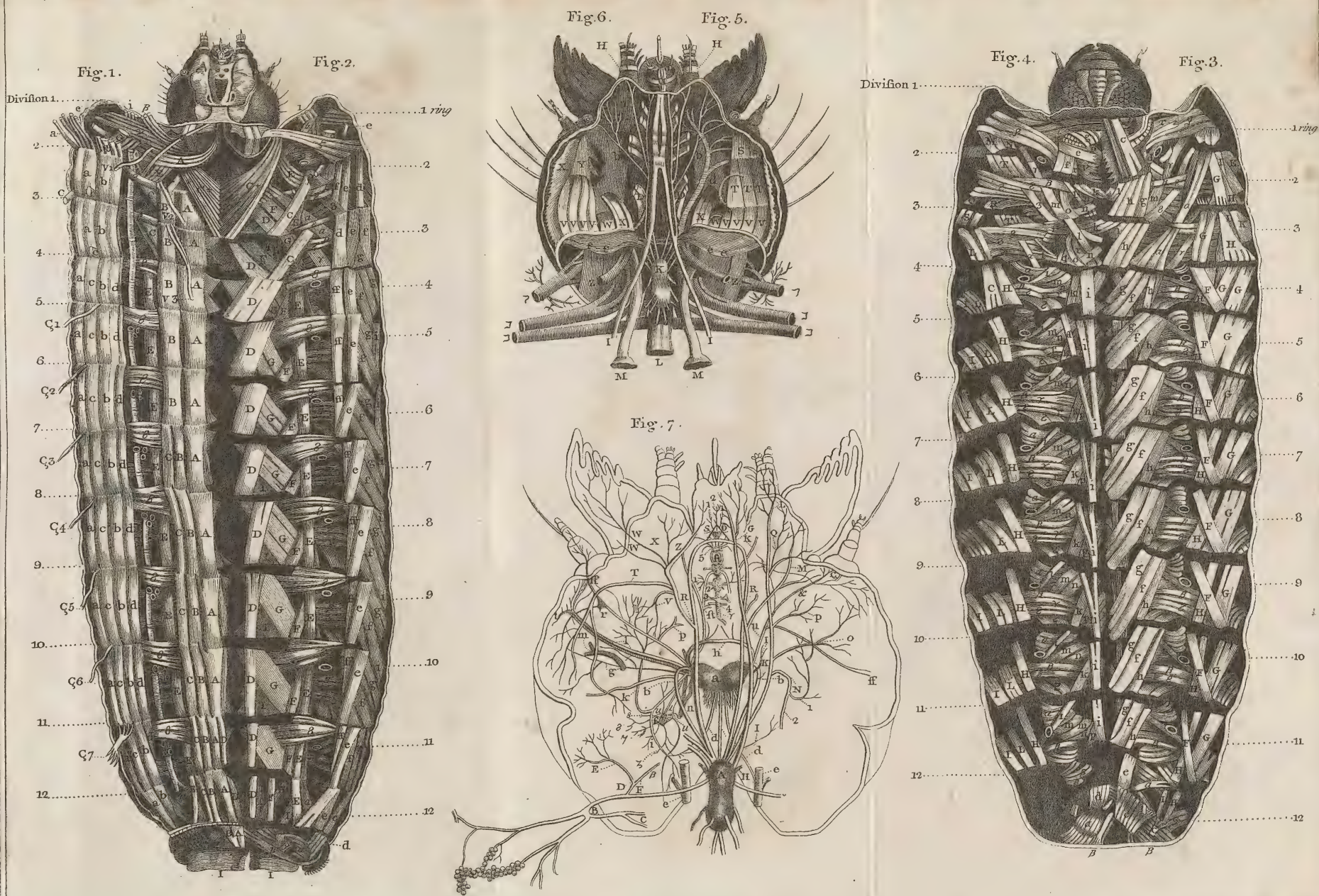
Je proposerai ici pour modèle à tous les anatomistes, ce célèbre scrutateur de la nature à la sagacité & au burin duquel nous devons le merveilleux *Traité Anatomique de la chenille*; ouvrage immortel dont nous n'avions pas même soupçonné la possibilité, & que je regarde comme la plus belle preuve de fait de l'existence d'une PREMIERE CAUSE INTELLIGENTE. Avec quel plaisir & quel étonnement ne lit-on point ces mots à la page xiii. de la Preface: " Comme je ne me suis proposé de publier qu'un simple
 " *Traité d'Anatomie*, l'on ne doit pas s'attendre à trouver ici de
 " grand details physiologiques; cette partie, si pleine d'incertitudes, pour être exposée comme il faut, auroit exigé nombre
 " d'expériences, que la répugnance que j'ai à faire souffrir les
 " animaux, ne m'a pas permis de tenter; répugnance, qui est
 " même allé si loin, que j'ai usé de la plus grande épargne par
 " rapport à mes sujets, & que je ne crois point que tout ce traité
 " ait coûté la vie à plus de huit ou neuf chenilles. Encore ai-je



J. Meire del.

16. May 20 1787.

J. L. B. de Vulp.





“ eu toujours soin de les noyer dans de l'eau avant que de les ouvrir.” Si GELON stipuloit pour l'humanite.* Quand il interdisoit aux Carthaginois vaincus, les sacrifices humains; LYONET stipuloit pour l'animalité quand il tracoit ainsi les devoirs de l'anatomiste, en se peignant si naïvement lui-même.

DESCRIPTION OF FIG. 1, PLATE XIII.

OF THE LEPAS ANATIFERA, OR BARNACLE.

This is a very peculiar species of shell-fish; the shell is not composed of two pieces, or valves, as is the usual case, but of five; two of these are larger than the rest, to which are affixed two smaller ones; the fifth piece is long, slender, and crooked, running down lengthways, and covering the joinings of the other pieces. It is a tender and brittle shell-fish, in length about an inch, it's diameter about three quarters of an inch. The shell part is of a pale red, variegated with white; it adheres to a neck, or pedicle, of an inch long, and about a fifth of an inch in diameter; by which means it is affixed to old wood, to stones, and sea plants, or any other solid substance that lies under water. It can shorten or extend this neck at pleasure, which resembles a small gut, and is usually full of a glarious liquor; it is composed of two membranes, an external one, hard and brown, an internal one, soft, and of an orange colour. The larger portions of the shell open and shut in the manner of the bivalves; the others, being moveable by means of their membranous attachments, give way

* MONTESQUIEU, *Esprit des Loix*.

way to the opening of these, and to the motions of the body of the fish, in any direction. It is furnished with a cluster of filaments, placed in a row on each side, sometimes fourteen in number. They are a kind of arms, appropriated for catching its prey, and therefore placed so as to surround the mouth of the animal, which is situated between them, and consequently easily receives what they thrust towards it. By the motion of these arms, which may be exerted in such a manner, as to play either within or without the cavity of the shell, it forms a current of water, which brings with it the prey they feed upon. Fig. 1, Plate XIII. represents two of these arms, or horns, as seen with the microscope. Fig. 2 represents the natural size of those from which these drawings were made. Each horn consists of several joints, and each joint is furnished on the concave side of the arm with a brush of long hairs. The arms, when viewed in the microscope, seem rather opaque; but they may be rendered transparent, and form a most beautiful object, by extracting out of the interior cavity a bundle of longitudinal fibres, which runs the whole length of the arm. Mr. Needham * thinks the motion and use of these arms illustrates the nature of that rotatory motion, which some writers have thought they discovered in the wheel animal.

In the midst of the arms is a hollow trunk, consisting of a jointed hairy tube, which incloses a long round tongue, that the animal can push occasionally out of the tube or sheath, and retract at pleasure. The mouth of this animal is singular in its kind, consisting of six laminae, which go off with a bend, indented

* Needham's Microscopical Observations.

dented like a saw on the convex edge, and by their circular disposition are so ranged, that the teeth in the alternate elevation and depression of each plate act against whatever intervenes between them. The plates are placed together in such a manner, that, to the naked eye they form an aperture not much unlike the mouth of a contracted purse.

The western isles of Scotland, and some other parts of the British dominions, are abundantly stored, at certain times of the year, with a bird of the goose kind, commonly known in those places by the name of the brent goose, or barnacle. These birds rarely breed with us, but seek for their fitting season islands less frequented than those where we find them in common. The seeing the birds so frequent, and yet never finding any of their nests, induced ignorant people to believe they never had any, and that they were not bred like other birds.

About the very shores where these birds are most common, the *Iepas anatifera* is also found in great abundance. The fishermen, who observed great quantities of these shells affixed to rotten wood, or dead trees, that were floating in the water, or lodged by it on the shore, were soon led to imagine that the filamentous substances which hung out of them resembled feathers, and persuaded themselves that the geese, whose origin they could before by no means make out, were bred from them, instead of being hatched, like other birds, from eggs.* It was afterwards affirmed, that the shells themselves originally grew on the trees, in the manner of their fruit: and from this arose the opinion that the barnacle, or brent goose, was the produce of a tree.

X x

Or

* Hill's Natural History of Animals.

OF THE PROBOSCIS OF THE BEE, FIG. 3 AND 4, PLATE XIII.

The more we penetrate into the hidden recesses and internal parts of nature, the more we find it marked with perfection in form and design. This position is so clearly proved in the little apparatus we are now about to describe, that Swammerdam,* speaking of it, says, that he cannot refrain from confessing, to the glory of the immense and incomprehensible Architect, that he had but very imperfectly described and represented this little apparatus; for to represent it to the life in it's full perfection, as truly most perfect it is, far exceeds the utmost efforts of human knowledge.

Soon as the matin glory gilds the skies,
Behold the little virtuosi rise!
Blithe for the task, they preen their early wing,
And forth to each appointed labour spring.
Now nature boon exhales the morning steam,
And glows and opens to the welcome beam;
The vivid tribes amid the fragrance fly,
And ev'ry art, and ev'ry business ply.
Each chymist now his subtle-trunk unsheathes,
Where from the flower the treasur'd odour breathes;
Here sip the liquid, there select the gum,
And o'er the bloom with quiv'ring membrane hum.
Still with judicious scrutiny they pry,
Where lodg'd the prime essential juices lie;
Each luscious vegetation wide explore,
Plunder the spring of every vital store::

The

* Swammerdam's Book of Nature, p. 195.

The dainty suckle, and the fragrant thyme,
 By chymical reduction, they sublime,
 Their sweets with bland attempering suction strain,
 And curious thro' their neat alembicks drain;
 Imbib'd reclusè, the pure secretions glide,
 And vital warmth concocts th' ambrosial tide.

BROOKE.

By the proboscis, or trunk, the bee not only procures itself necessary subsistence, but it is also employed by the animal to collect the honey, which we appropriate to ourselves as if it was made for us. It may be considered in a general view as consisting of seven pieces; one of these, *i i*, *b c*, Fig. 3, Plate XIII. is placed in the middle; this is supposed to be pervious, and to constitute what may be properly called the proboscis. The other six smaller parts, or sheaths, disposed in three pairs, are placed on each side the former. They not only assist it in extracting and gathering the honey from the flowers, but they also protect and strengthen it. The proboscis (*i i*, *b c*) itself is very curiously divided; the divisions are elegant and regular, and are beset all round with bristly triangular hairs, distributed in an elegant order: these divisions, though very numerous, appear at first sight as a number of different articulations.

The two pieces *a a* of the exterior sheath are of a substance partly between bone and horn, and partly membranaceous; they are set round with hairs, and are furnished with air vessels, which are distributed through their whole texture; the upper ends *f f* of this sheath appear to be a little bent, but can be straitened by the bee when they are applied to the proboscis. At *d d* are two

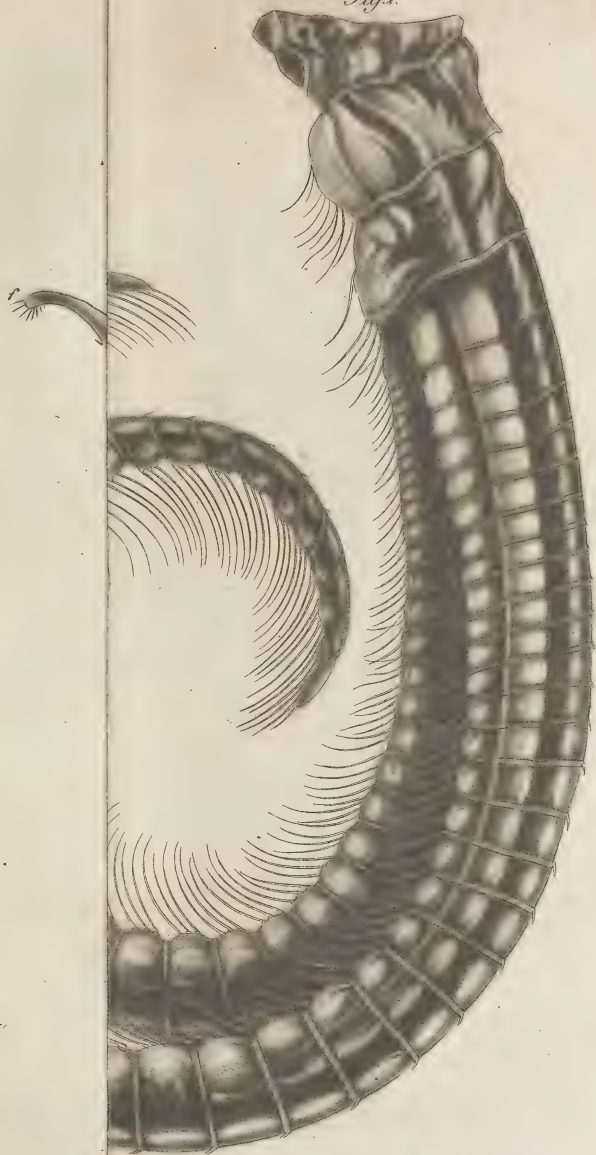
X x 2

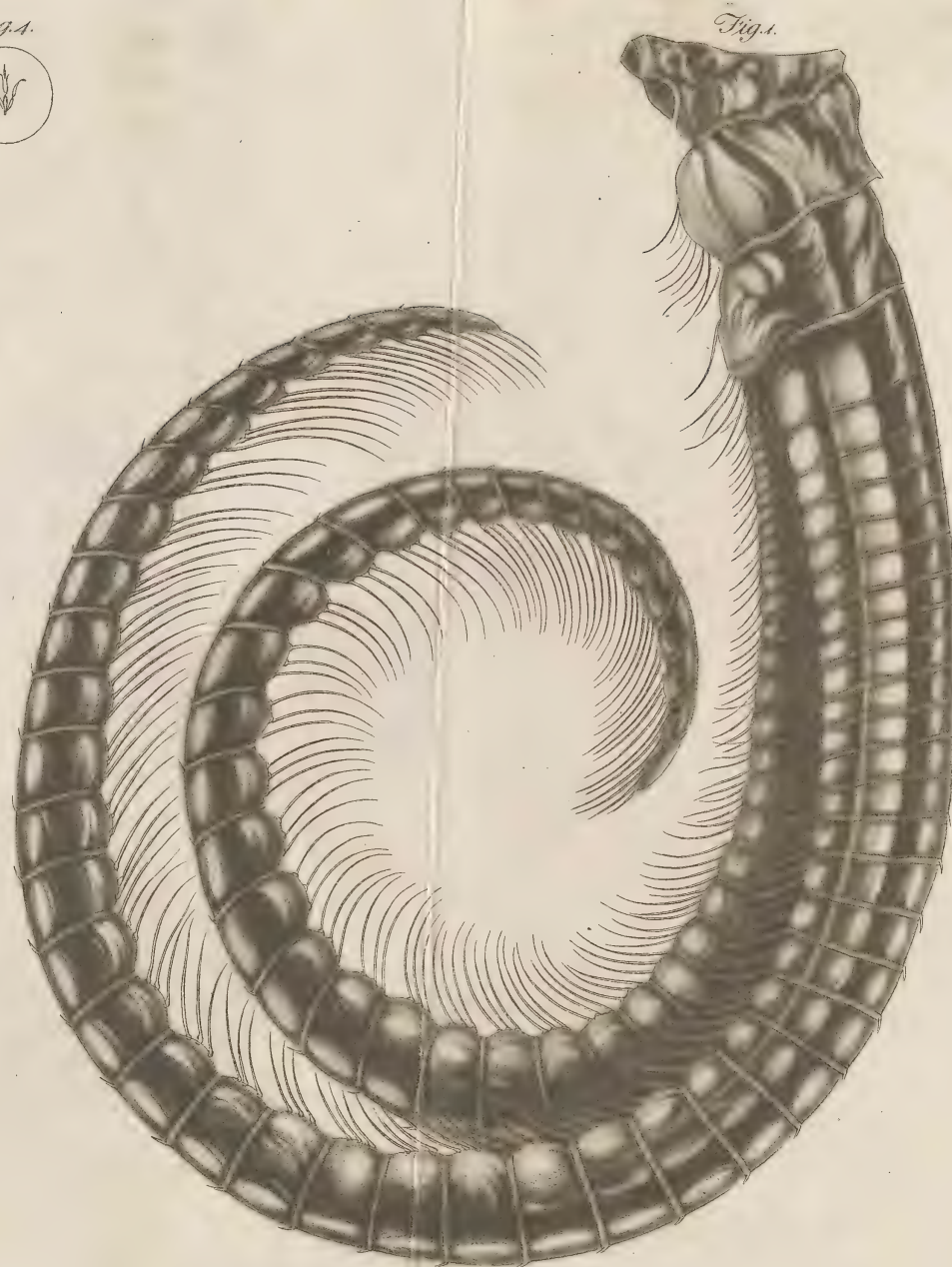
articu-

articulations, by means of which the pieces a a may be occasionally bent. The joints contribute towards bending the proboscis downwards, or rather underneath, against the head. These sheaths, together with the two interior ones e e, assist in defending, covering, and protecting it from injuries: it is also probable that they forward the descent of the honey, by pressing the proboscis. The parts k k of this sheath have been called by some writers the root.

The two parts e e of the interior sheath are placed higher than those of the exterior one; they originate at g g on the proboscis itself, and near that part, or articulation, by which the bee can upon occasion bend the proboscis; this sheath, therefore, always moves with the middle part i i, and is carried forward by it, the exterior sheath being left behind, because its attachments and origin are below that of the proboscis. The pieces e e are very similar in structure to those of a a, only that each of them has on the upper part three joints; the lower one is much longer than the other two; they are all of them surrounded with short hairs. The smaller articulated pieces never lie close to the proboscis, nor cover it, but are only placed near it, the two upper joints projecting outwards, as in this figure, even when the whole apparatus is shut up as much as possible. Swammerdam thinks these joints are of essential use to the bee, acting as it were in the manner of fingers, and assist the proboscis, by opening the leaves of the flowers, and removing other obstructions from it: or like the two fore feet of the mole, by the help of which it pushes the earth from the sides both ways, that it may be able with its sharp trunk to search for its food more conveniently. There are two smaller pieces, or sheaths,

Fig. 1.





sheaths, m m, near the bottom of the proboscis; these cannot be well seen without removing the sheath e e.

The proboscis is partly membranaceous, and partly of a gristly nature; the lower part is formed in such a manner, that it will swell out considerably, by which means the internal cavity may be prodigiously enlarged, and rendered capable of receiving a very large quantity of native and undigested honey, and larger than might be expected from its size. When the proboscis is shut up and inactive, it is very much flattened, and is three or four times broader than it is thick. The edges are always round; it grows tapering, though very gradually, towards the extremity. The lower and membranaceous part of the trunk has no hair on it, but is covered with little protuberant transparent pimples, that are placed in regular order, and at equal distances from each other, resembling the little risings observable on the skin of birds when the feathers have been plucked off. They are probably glandules, and may have a considerable share in changing or preparing the honey that is swallowed or taken up by the proboscis. Down the middle of the proboscis there is a tube of a much harder nature than the sides, it grows gradually smaller towards the top; at this place the proboscis is very thick set with small hairs; whether they are open tubes, or whether they only serve as so many claws, to keep it in its proper place while in action, has not been determined.

The proboscis terminates in a small cylinder c, at the top of which there is a little globule, or nipple; the circumference of the upper part of this cylinder is beset with hairs, which radiate from it; the bee can contract this cylindrical part, and the little membrane,

membrane, in which the hairs are fixed, into a much smaller compass, and draw it inwards,

The proboscis is not cylindrical, but rather a kind of convex blade, terminating nearly in a point; and the sheaths are so contrived as to cover little more than the upper part of it; they are a kind of angular groove, of which the upper side is the broadest. The exterior sheaths lap over each other on the upper part, so that the outside of the proboscis is protected by a very strong double case, a covering that was unnecessary for the under part; because when this instrument is in use the sheaths are opened, but when it is inactive it is so folded that the under part is protected by the body of the bee. Within side the exterior sheath, and near the bottom *q*, are two levers, which are fixed to the end of the proboscis, and by which it is raised and lowered.

If a bee is attentively observed when it has placed itself upon a full-blown flower, the activity and address with which it uses this apparatus will be very conspicuous. It lengthens the end of it, and applies it to the bottom of the petals, or leaves, of the flower, moving it continually in ten thousand different ways, lengthening and shortening it, bending and turning it in all possible directions, to adapt it to the form of the leaves of the flower. These various movements are executed with a promptitude that surpasses all description.

Mr. Swammerdam thinks that the honey is, as it were, pumped or sucked up by the bee through the hole at the end *b* of the proboscis; he does not seem to have discovered the apertures which are on the cylindrical part, near the end *b*.

M. Reau-

M. Reaumur thinks it is used as a tongue to lap up the fluid which is conveyed down between the sheath to the mouth of the bee. To prove this, he placed a bee in a glass tube, the inside of which was rubbed over with honey, and little pieces thereof placed in different parts; he observed the trunk lying on the honey, the end thereof being stretched beyond the honeyed heap; she bends it into the form of a bow, and inserts the most convex part of this bow into the liquor, and then rubs the glass backwards and forwards with the same side of the proboscis, so as very soon to clean that part of the glass to which she applies it. It is afterwards conveyed to the throat by the various vermicular motions of the proboscis. Those who wish for a fuller account of this curious apparatus, will do well to consult the interesting memoirs of M. de Reaumur, who has, with a wonderful sagacity, discovered the principal springs of this astonishing machine. He has there described more than twenty parts of which it is made, and almost given a complete anatomy of this little organ. Like a workman who takes to pieces a watch which he himself has made, he lays before us the several pieces, makes us remark their fitness, their adjustment, their uses, the play of their springs, pivots, and pillars; for all these parts, and many more, are to be found in the proboscis of the bee.

OF THE WINGS OF INSECTS:

The attentive observer will find a very pleasing variety of objects in the wings of different insects. The beauty of their colours, the delicacy of their structure, the art with which they are connected to the body, the curious manner in which some are folded up, the admirable texture of their joints, impress on the
mind.

mind a deep sense of that wisdom, which is manifested in such various ways through the whole works of creation.

The delicate transparent wings of many insects are covered and protected by elytra, or cases, which also in some measure act as wings.—These

“——A two-fold apparatus share,
 Natives of earth, and habitants of air;
 Like warriors stride, oppress'd with shining mail,
 But furl'd beneath their silken pennons veil:
 Deceiv'd, our fellow reptile we admire,
 His bright endorment, and compact attire;
 When lo! the latent springs of motion play,
 And rising lids disclose the rich inlay;
 The tissued wing it's folded membrane frees,
 And with blithe quavers fans the gathering breeze.*

The exterior cases are harder and more opaque than the under ones; they are generally highly polished, and often enriched with various colours, adorned with ornamental flutings, and studded with brilliants. All these ornaments are united in the *curculio imperialis* † (or diamond beetle), one of the most resplendent creatures in nature; the head, the wings, the legs, &c. are curiously beset with scales of a most brilliant view, out-vying the ruby, sapphire, and emerald. It is said, that in the Brazils, from whence they come, it is almost impossible to look at them

* Brooke's Universal Beauty.

† Fabricius Spec. Inf. 184. 129.—Drury, Inf. 2 Tab. 33, Fig. 1.

them on a sunny day, when they are flying in little swarms, so great is the glowing glory of their heightened colours.

The strength and hardness of the elytra are admirably adapted to the various purposes of the insects to which they are appropriated, and at the same time that they protect the tender wing, they serve as a shield to the body; the ribs, and other prominencies, on many of them, contribute to lessen the friction, and diminish the pressure to which they are often exposed.

In most of these insects the under wing is longer and larger than the exterior one, so that it is obliged to be bent and folded up, in order to lie under the elytra; for this purpose they are furnished with strong muscles, and proper articulations, to display and conceal them at pleasure. Fig. 2, Plate XIV. represents the wing of the earwig* when unfolded, and of its natural size. Fig. 1 represents it as exhibited by the microscope. We shall describe this more particularly hereafter.

We have already treated of those decided differences in the wings of insects, which assist the natural historian in ranging them into classes; so infinite are the varieties to be observed in this curious organ, that only to enumerate them would occupy many pages; we must, therefore, content ourselves with a few general remarks, leaving it to some future writer to display the wonders that are manifested in their disposition, structure, motions, and ornaments. In general, the wings are delicate and yet strong, furnished with ribs, or nerves, curiously insculcated

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together,

* *Forficula auricularia*, Lin. Syst. Nat. vol. 1, part 2, 686-1.

together, so as to strengthen and convey nourishment to the several parts of the wing, while by the diversity of their ramifications they add to it's beauty; many have their wings fortified with bristly hairs; which they can erect at pleasure, Plate XV. Fig. 1.

The wings of the moth and butterfly are mostly farinaceous, being covered with a fine dust, which renders them opaque, and is also the cause of those beautiful and variegated colours which so richly adorn them, that

“Not all the shew and mockery of state,
The little, low, fine follies of the great;
Not all the wealth which eastern pageants wore,
What still our idolizing worlds adore,
Can boast the least inimitable grace
Which decks profuse this illustrious race.”

Ever since the microscope was invented, this dust has engaged the attention of the microscopic observer. For by this instrument it is found to be a regular assemblage of organized scales, of various shapes and colours, some long and slender, some short and broad, some notched at the edges, others smooth, generally furnished with a kind of foot stalk, by which they are fixed to the wing, see Fig. E F H I, of Plate XVI. Their shapes are not only very different in moths of various species, but of those on the same moth some will be found to be nearly oval, while others are triangular; a variety of large stripes, or ribs, are to be discovered in these scales, and between these larger ramifications minuter lines may be seen; the larger stripes seem in general to
rise

rise from the exterior notches ; some of these scales, or plates, are to be found so exceedingly slender, that it is not easy to discriminate them from hairs by the naked eye. The regular arrangement of these plates, one beside, and partly covering the other, as in the tiling of a house, is best seen by examining the wing in the opaque microscope. The prodigious number of small scales which cover the wings of these beautiful insects, is a sure proof of their utility to them, because they are given by HIM who makes nothing in vain.

That the lively and variegated colours which adorn the wings of the moth and butterfly arise from the small scales, or plates, that are planted therein, is very evident from this, that if they are brushed off from it, the wing is perfectly transparent ; but whence this profusion and difference of colour on the same wing ? is a question as difficult to resolve as that of Prior, when he asks,

“ Why does one climate and one soil endue
The blushing poppy with a crimson hue,
Yet leave the lilly pale, and tinge the violet blue ? ” }

The materials of the wings under these plates seem to be of a talc nature ; the wing is strengthened by several nerves, or ribs, which run through it ; the largest fortifies the exterior edge of the wing, while a smaller one strengthens the interior edge. When the moth immenges from the chrysalis, the wings are soft and thick, and if they are examined at that time, they will be found to consist of two membranes, which may be raised up, and

then separated, by blowing between them with a small tube. The vessels, or ribs, lie between these skins.

As the wings of the moth and butterfly are light, they can support themselves for a long time in the air; their manner of flying is ungraceful, mounting and descending alternately, so that they generally move in a zigzag line, to the right and to the left, up and down; by this means they often escape the birds who chase them, as this undulating motion disappoints them in their aim: hence they often may be seen to pursue a butterfly in vain for a considerable time.

Dr. Hooke * endeavoured to investigate the nature of the motions of the wings of insects; and although he was not able, from the experiments he made, to give a satisfactory account of them, yet as they may be useful to some future inquirer, and lead him more readily into the path of truth, I hope an extract therefrom will not prove unacceptable to the reader. To investigate the mode or manner of moving their wings, he considered with attention those spinning insects that suspend, or as it were poise themselves, in one place in the air, without rising or falling, or even moving backwards or forwards; by looking down on these he could, by a kind of faint shadow, perceive the utmost extremes of the vibratory motion of their wings; the shadow, while they were thus suspended, was not very long, but was lengthened when they endeavoured to fly forwards. He next tried, by fixing the legs of a fly upon the top of the stalk of a feather, with glue, wax, &c. and then making it endeavour to fly away; he was thereby

* Hooke's Micrographia, p. 172.

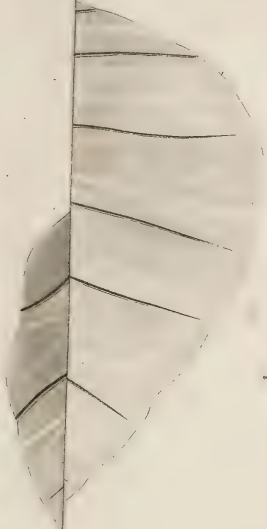


Fig. 2.

Fig. 1.



Fig. 2.





thereby able to view it in any posture. From hence he collected, that the extreme limits of the vibrations were usually somewhat about the length of the body distant from each other, often shorter, and sometimes longer. The foremost limit was generally a little above the back, and the hinder one somewhat beneath the belly; between these, to judge by the sound, they seemed to move with an equal velocity. The manner of their moving them, if a just idea can be formed by the shadow of the wing, and a consideration of it's nature and structure, seemed to be this: the wing being supposed to be in the extreme limit; it is then nearly horizontal, the fore part only being a little depressed; in this situation the wing moves to the lower limit; before it arrives at this, the hinder part begins to move fastest; the area of the wing begins to dip behind; and in that posture it seems to be moved to the upper limit back again. These vibrations (judging by the sound, and comparing them with a string tuned in unison thereto) consist of many hundreds, if not thousands, in a second of time. The powers of the governing faculty of the insect, and the vivacity of it's sensations, whereby every organ is stimulated to act with so much velocity and regularity, surpass our present comprehension.

Fig. 1, Plate XV. is a representation of the wing of the *hemerobius perla* (Lin. Syst. Nat. vol. 1, part 2, page 911-2) of the natural size. Fig. 2 represents the same wing magnified. This elegant insect has acquired the name of *hemerobius* from the shortness of it's life, as it seldom lives more than two, or three days in it's fly state: Linnæus has placed it in his fourth class, among those insects which have four transparent wings and no sting. The wings are nearly of a length, and exactly similar; they

they are composed of delicate fine nerves, regularly and elegantly disposed, as may be seen in the figure; they are beautifully adorned with hairs, and are slightly tinged with green. The body is of a fine green colour, and it's eyes appear like two delicate beads of burnished gold, from whence it is by many called the golden eye. This curious little insect lays it's eggs on the leaves of the plumb, rose tree, &c. the eggs are small and white, and each of them fixed to a little pedicle, or foot stalk, about half an inch long; they stand off from the leaf, and appear much like the fructification of some of the mosses. This singular circumstance has been already noticed in page 265 of these essays. The larva which proceed from these eggs resemble that of the coccinella, or lady cow, but are much handsomer; it feeds like them on the aphides, or pucerons, sucking their blood, and forming itself a case with their dried bodies, in which it changes into the pupa state, from whence they afterwards immerse in the form of the fly here described.

Fig. 2, Plate XIV. represents the wing of the forficula auricularia, or earwig, (Linn. Syst. Nat. vol. 1, part 2, page 685-1) of the natural size. Fig. 1, the same wing magnified. Though this insect is so very common, yet few people know that they have wings, and fewer yet have seen them; they are of a curious and elegant texture, and wonderful structure. The upper part is crustaceous and opaque, while the other part is beautifully transparent. It folds up into a very small compass, and lies nearly concealed under the elytra, which are not more than a sixth part of the wing in size. They first fold back the parts A B, and then shut up the ribs like a fan; the strong muscles used for this purpose are seen at the upper part of the figure. The ribs are extended
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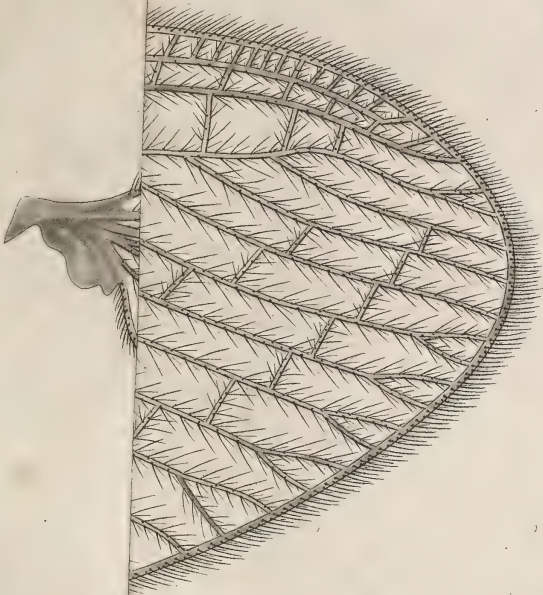


Fig. 1.

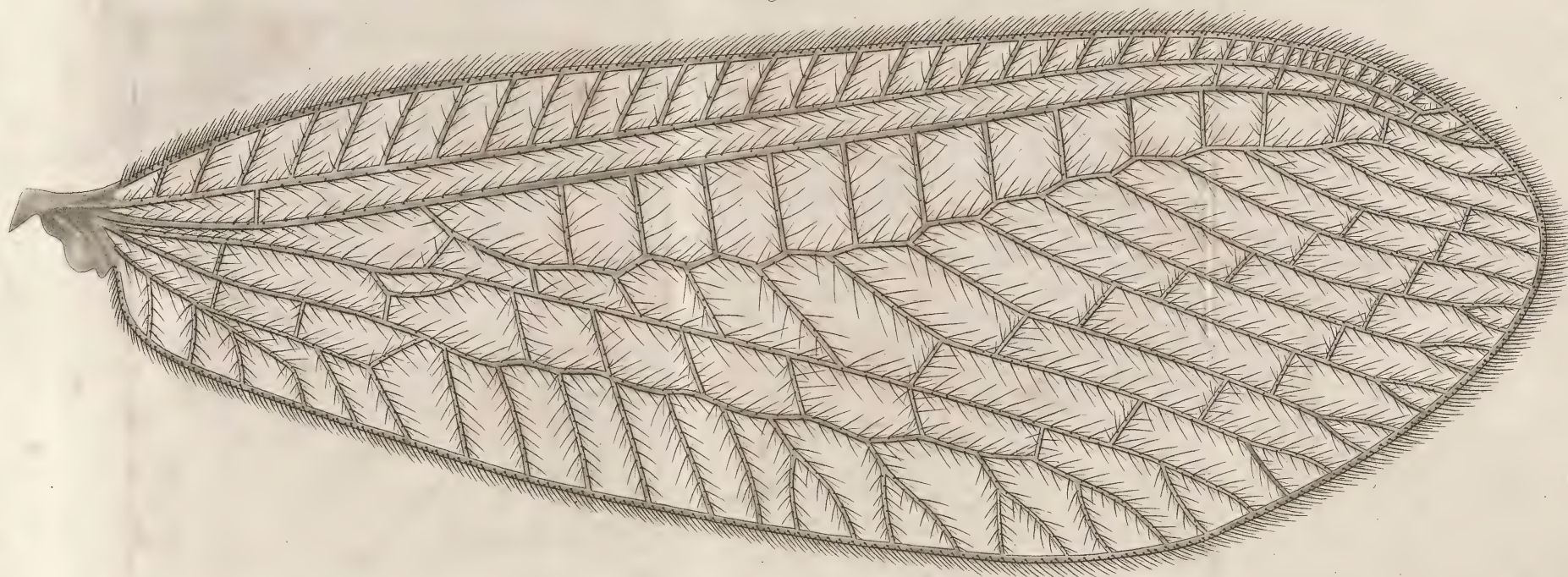


Fig. 2.



from the center to the outer edge, others are extended only from the edge about half way, but they are all united by a kind of band, at a small but equal distance from the edge; the whole evidently contrived to strengthen the wing, and facilitate the various motions thereof. The earwig is a very destructive animal, doing considerable injury to most kinds of wall fruit, to carnations, and other fine flowers, &c. and as they only feed in the night, they escape the search of the gardener. Reeds open at both ends, and placed among fruit trees, are a good trap for them, as they crowd into these open channels, and may be blown out into a tub of water. As they conceal themselves in the day-time, those that are curious in flowers place tobacco pipes, lobster claws, &c. on the top of their garden sticks, in order to catch them. This insect differs very little in appearance in its three different states. De Geer asserts, that the female sits on her eggs, and broods over the young ones as a hen does over her eggs.

OF THE EYES OF INSECTS.

The construction and formation of the eyes of insects differs considerably from that of other animals. In other creatures the eyes are moveable, and generally placed one on each side of the head, and two are sufficient for all the purposes of vision. But in insects the eyes are fixed, and therefore would not serve to give them a view of any object but what was placed directly before them. We therefore find that they are provided with a number of eyes, which in some species, as in the spider, are single, and placed at some distance from each other. But the greater part
are

are furnished with a collection of an indefinite number of very small single eyes, placed in one common case or socket.

The two protuberances on the head, which are formed by this congeries of eyes, seem to the naked eye to consist of a number of lines, crossing with great regularity and exactness, at some little distance from each other, like the meshes of a net, from whence they have been termed the reticular eyes. Those of the libellula are peculiarly well adapted, on account of their size, for a microscopic view of this subject. These eyes are so perfectly smooth and polished, that when viewed as an opaque object, they will, like so many mirrors, reflect the images of all the surrounding objects. The figure of a candle may be seen multiplied almost to infinity on their surfaces, shifting it's beam to each eye according to the motion given it by the observer's hands. Other animals are obliged to turn their eyes towards any object, but these have eyes ready directed to it, on whatever side it may present itself. The genus of cancri have their eyes moveable, but for the most part reticulated like other insects.

Though the reticulated eyes of flies are large, not only in proportion to the size of the creature, but absolutely and in themselves; yet the several small eyes, of which they are composed, are remarkably minute in comparison of those of the butterfly class.

Most of the butterfly class have in each of their reticulated eyes many thousand small ones; but the fly class greatly exceed them in the number of these; as many of their eyes are three times as large as those of the butterfly, and besides that each smaller eye is vastly more minute.

Mr. Hook computed 14,000 hemispheres in the two eyes of a drone; Mr. Leeuwenhoeck reckoned 6236 in a silk-worm's two eyes in it's fly state; 3181 in each eye of a beetle, and 8000 in the two eyes of a common fly. The pearl eyes of the dragon fly appear with a common reading-glass like flagreen, and Mr. Leeuwenhoeck reckoned in each eye of this insect 12,544 lenses, placed in an hexangular position, each lens having six others round it. He also observed in the center of each lens a minute transparent spot, brighter than the rest, supposed to be the pupil, surrounded with three circles, and in appearance seven times less than the diameter of the whole lens. Mr. Puget counted 17,325 in the eye of a butterfly, which Malpighi concludes to be distinct and separate eyes. The Abbé Catalan, and others, have since shewn, that all the eminences discoverable in the cornea of insects have the necessary parts, and perform the offices of an eye. Leeuwenhoeck discovered the bundles of optic nerves which serve these small lenses; and Reaumur supposes that these supply the place of all that is wanted behind the lenses, for the organization of an eye complete for vision.

But it is in the works of Swammerdam that we are enabled to contemplate the astonishing organization of the eyes of insects. Under each mesh, or facet, there is a little pyramid of fibres, broad at the base, and growing smaller as it proceeds inwards. The pyramids have the same number of sides as each eye, and there are, therefore, as many hexagonal pyramids as there are small facets, or eyes, in the insect. An innumerable quantity of pulmonary tubes ascend these fibres; these tubes terminate in a fine transparent white fibrous membrane, of a convex shape, which is also thick set with pulmonary tubes; under this mem-

brane is another, which is more delicate and more transparent; but connected with it by means of pulmonary tubes; under this there is placed a second species of fibres, transversely applied, like so many beams, to support the pyramidal fibres that are laid over them.

Each side of the head of a fly, which is cut as it were into a multitude of small facets, is one of the reticulated eyes of the creature. Nature allots two of these reticulated eyes to each fly; and as they each contain such a vast multitude of smaller, but perfect eyes, one would imagine them to be very sufficient for all the occasions of the animal. There are, however, certain flies of the ephemera kind which have four of these reticulated eyes, two of which are placed as is usual in the musca, and are but of small extent; the other two have each the appearance of a sort of turban, and are placed one beside the other upon the upper part of the head.

These have somewhat the figure of a mushroom, the head of it extended a little beyond the stalk, and the upper convex surface cut into almost an innumerable quantity of facets.

The first pair of the reticular eyes of this fly, which are placed as those of the other flies, are in colour brown; those of the mushroom form are of a very beautiful citron-colour, and as transparent as the most pellucid reticular eyes of other flies; for, among the various species, some have these eyes much more transparent than others. The fly, thus remarkably furnished with eyes, is produced from a worm of the same kind with the common species of ephemerons; its body is of a pale yellow,
and

and it's wings white; the two inferior ones of these are so small, that they are not easily distinguished.

Among the fly class these reticular eyes are, in different species, of different colours; there are some which have them brown, others yellow, others green, and others red, and this in all the different shades of those colours. Some of them have also the gloss of metals highly polished, others afford us a view of changeable colours, and others have arrangements of different colours, fixed and invariable. The eyes of one species of the gad-fly, so troublesome to oxen, have streaks of red, green, and brown, placed alternately.

One would imagine, that as every fly has two of these reticular eyes, each composed of such a multitude of real eyes, they could have no occasion for any more; but so it has not appeared to the great Being that formed them, for many species are furnished with more eyes, which differ both in construction and form from those that are reticulated.

The eyes already described are properly called reticular ones; and to avoid confusion, it will be necessary to describe those which differ from them by some determinate name (they are now generally termed the *stemmata*); these, when examined by the best microscopes, appear of a perfectly smooth, glossy, and polished surface, but plain and simple, without the least appearance of a reticulated texture. They are also much smaller than the reticulated eyes, and may therefore be called, by way of distinction, the smaller smooth eyes, or the *stemmata*.

M. De la Hire seems to have been the first person who discovered these smooth eyes. He observed three of them disposed in a triangular form, on the back part of the heads of some of these little creatures. He soon found that they were transparent, and thence naturally judged them to be of the same nature of the cornea of our eyes, and really to serve the same office to the creature possessed of them.

We find three of these smooth eyes placed triangularly on the back part of the head of vast numbers of the genera of flies, as well of the two-winged as of the four-winged kinds; but there are also some of both these classes, in which they are wanting. All the species of gnats, and of tipulæ, are without them. The heads of these are very small in proportion to the bulk of their body, and are in a manner covered by their reticular eyes. The want of the small eyes is amply made up by the size and extent of the larger; but there are some other kinds which want them, without having this advantage in their place. Of the two-winged flies with short bodies, the gad-flies want these eyes; and among the longer bodied and four-winged kinds, the flies produced from the puceron-eaters (*hemerobius*).

Notwithstanding, therefore, that many species of flies have these eyes, there are yet so many that want them, that Mr. De la Hire would not have judged these to be their only eyes, if he had made experiments on the reticulated ones, in the manner of Mess. Swammerdam and Reaumur. Mr. Swammerdam put upon the eyes of certain flies a covering of black, steeped in oil; in this state they flew at random, and seemed to have no strength; and wherever they settled they did not avoid the hand which would

take them. M. Reaumur made also some experiments upon the reticulated eyes of bees, which were all taken from the same hive. He spread upon them a covering of dark-coloured varnish, and shut them up with some of their companions which had not been touched, in a large powder-box. At about eight or ten steps from the hive from whence they were taken, the cover of the box was taken off; those which had their eyes clear immediately took their flight, and went to their habitation; those whose eyes were varnished made no haste to get out of the box; they had some difficulty to determine themselves for flight, and the greatest number directed it at random, and on different sides, and went not far. To oblige some of them to fly farther, they were thrown into the air; they raised themselves vertically till they were lost, and not one of them seemed to know the way to it's hive.

To know what would happen if the stemmata were covered, he put varnish upon them, in the same manner as was done to the reticulated eyes, and set them likewise at liberty, about three or four steps from the hive; not one seemed to know it's way, or even seek it. They flew on all sides upon the plants, but did not fly far.

An insect is, I believe, never found with both kinds of eyes but when it is in it's perfect state. The moth, for instance, which has several thousands of eyes in the reticulated form, has only six small smooth eyes in the state of the caterpillar. The wonderful anatomist of the cossus has shewn, that the eyes of the latter are in the form of a cup, and that the cornea, which is the cover to this cup, is very transparent. He has been enabled to discover a true
optic

optic nerve, that divides into six branches, which are connected with each eye; each of these is accompanied with a pulmonary tube. This celebrated observer, in speaking lightly of the reticulated eyes of the moth of the coffus, which are in number 22,000, says, that each is probably a telescope, consisting at least of three lenses.

It is easy to shew with the eye of a fly, prepared as we have already described in page 142, chapter iv. and then placed before the microscope, that each of the portions of these reticular eyes have the power of refracting the light, and forming an image of a candle, or any other object, at their respective foci. Mr. Martin affirms, that in a great number of observations he always found that the edge of the cornea of each eye was always thicker in the middle than at the edges, and that this swelling out, or increase of thickness, was equal on each side, and exactly opposite, amounting to a full proof that the cornea of an insect's eye is really a system of a great number of exceeding small double and equally convex lenses, of an hexagonal form, "and affording one of the most striking instances of Divine geometry and optics."

Fig. 3, Plate XVI. is a representation of a small portion of the cornea of the libellula, as seen by the microscope. The sides of the hexagons, in some positions of the light, appear of a fine gold colour, and divided into three parallel lines. Fig. 4 is the same piece of it's natural size.

Fig. 5, Plate XVI. represents a piece of the cornea of a lobster's eye; in these each of the eyes are set as it were in a square frame. Fig. 6, the same piece not magnified.

Mr.



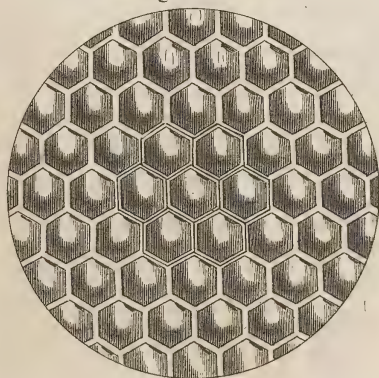
Fig. 2.



Fig. 4.



Fig. 3.



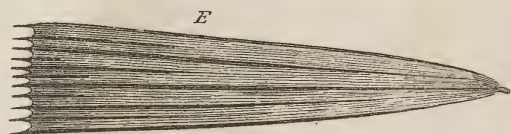
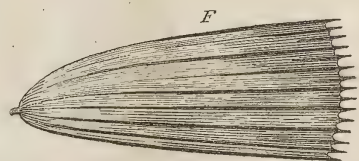


Fig. 6.



Fig. 5.

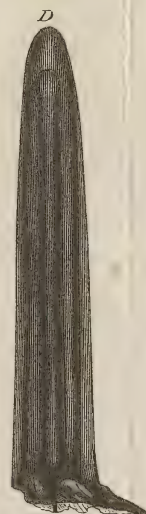
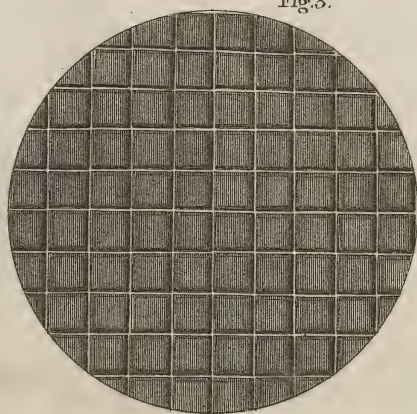


Fig. 1.

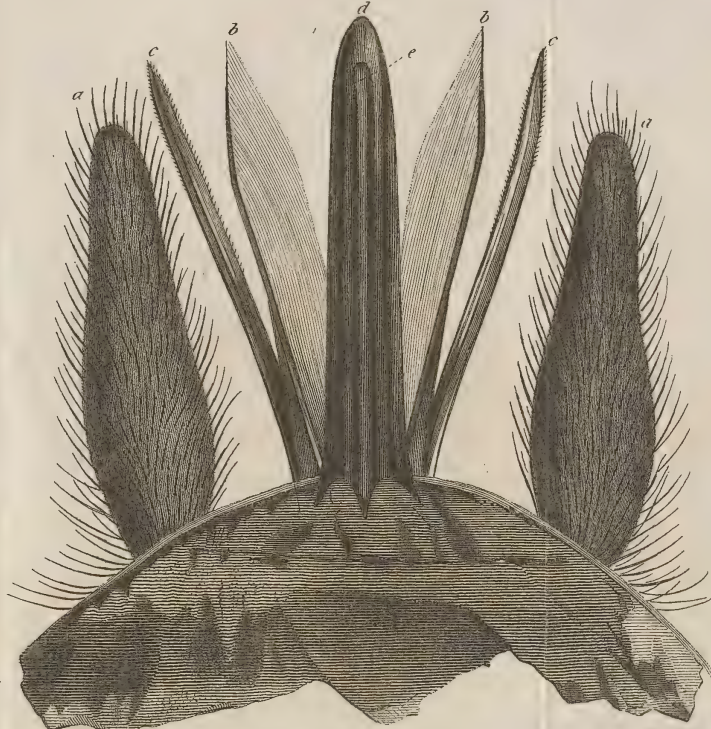


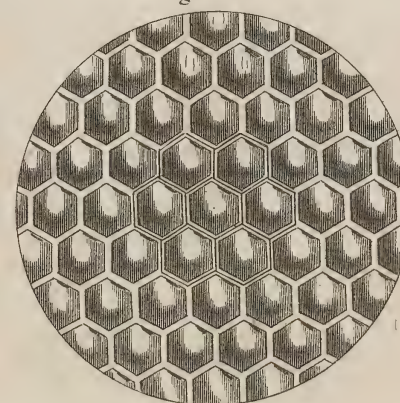
Fig. 2.



Fig. 4.



Fig. 3.



Mr. William André has shewn, that these are not the only variations which are to be found in the eyes of these small creatures; for those of the *monoculus polyphemus* are made up of a great number of small transparent amber-like cones. See his letter to Sir Joseph Banks, in the *Philosophical Transactions*, a short extract from which I shall proceed to lay before the reader.

“ The *monoculus polyphemus*, or king crab, is a crustaceous animal, found in all the seas surrounding the continent of America and the West India islands, and which frequently grows to a very large size.

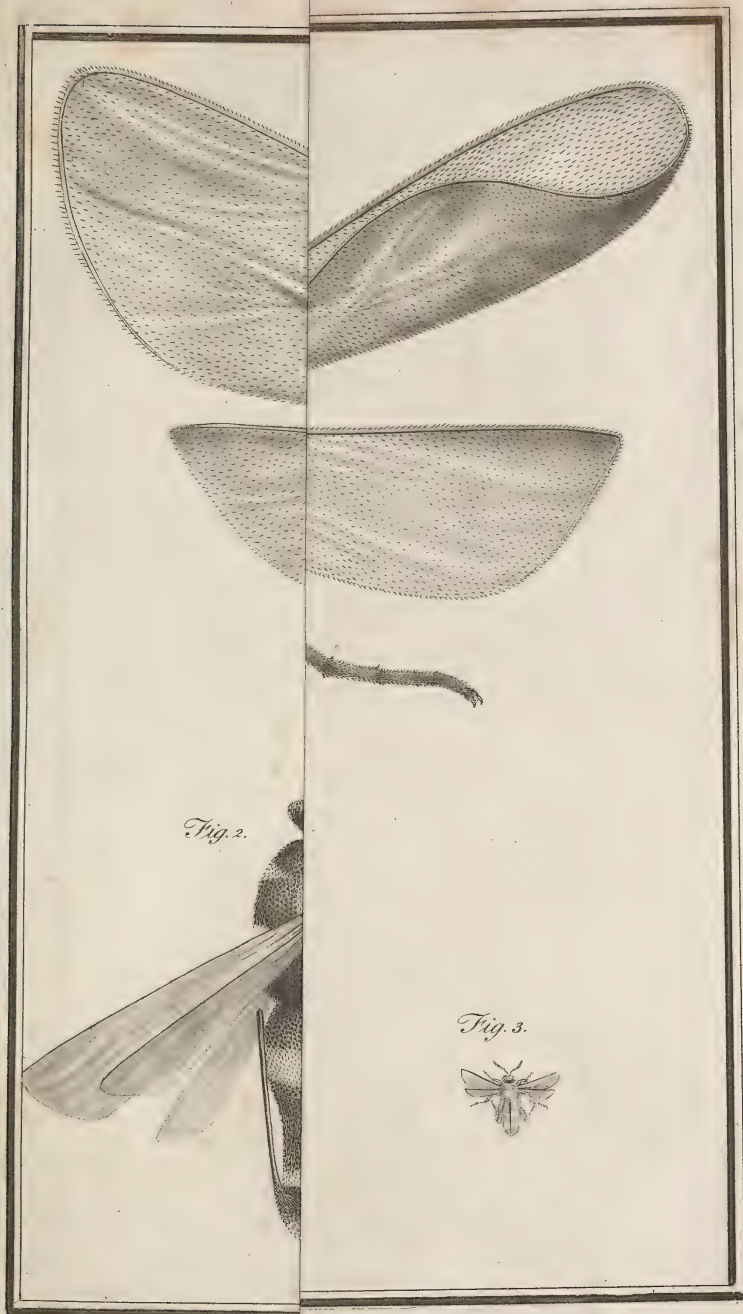
“ If the shell of the *monoculus* were divided fairly in half, the large eyes would be nearly in the center of each piece, and the small ones on the divided edge, near the fore-part of the shell. The large eyes are at a great distance from each other; but the small ones are close together. It will appear hereafter that the large eyes are made up of a great number of small transparent amber-like cones, and that the small ones are composed of one such cone only; so that they may be divided into eyes with many cones, and eyes with a single cone. The large eyes, or those with many cones, appear as two transparent spots, about the size and nearly of the shape of a kidney-bean, the concave edges looking towards each other, and the convex towards the edge of the shell. If they be examined attentively, we may discern on their surface a number of small depressions, which point out the center of each cone. The small eyes, or those with a single cone, look like two small transparent spots, not larger than a pin's head; these, from their minuteness, are easily overlooked.

“ The

“ The appearances which have been described may be seen on the external surface of the shell with the naked eye ; but in order to proceed to a further investigation of the subject, the cornea must be removed from the shell, and applied to a single microscope with a very strong light.

“ The internal surface of the large eyes, examined with the microscope, is found to be thick set with a great number of small transparent cones, of an amber colour, the bases of which stand downwards, and their points upwards next the eye of the observer. The cones in general have an oblique direction, except some in the middle of the cornea, about thirty in number, the direction of which is perpendicular.

“ The center of every cone being the most transparent part, and that through which the light passes, on that account the perpendicular or central cones always appear beautifully illuminated at their points. In a word, they are all so disposed, as that a certain number of them receive the light from whatever point it may issue, and transmit it to the immediate organ of sight, which we may reasonably suppose is placed underneath them ; the cones are not all of the same length ; those on the edges of the cornea are the longest, from whence they gradually diminish as they approach the center, where they are not above half the length of those on the edges.”







OF THE INSECT WHICH IS REPRESENTED AT FIG. 1, 2, 3,
PLATE XVII.

This very beautiful and singular insect was first pointed out to me by Mr. Marsham, who had seen it in the cabinet of insects belonging to the Queen, in the royal observatory at Richmond. Her Majesty was pleased to permit me to have the drawing taken from it, from which this plate was engraved. When Mr. Marsham first saw it at Richmond, he considered it as an undescribed insect, and an unique in this country. But he has since found that it is mentioned by Fabricius, in his *Systēma Entomologiæ*, as a new genus, under the name of *leucospis dorfgera*; and there is one of the insects in the cabinet of the celebrated Linnæus, now in the possession of J. E. Smith, M. D. F. R. S. Sulz, and other writers, have also described it.

It appears at first sight like a wasp, to which genus the folded wings would have given it a place, had not the remarkable sting, or tube, on the back removed it from thence. It is probably a species between, and uniting the sphex and wasp, in some degree partaking of the characters of both. The antennæ are black and cylindrical, increasing in thickness towards the extremity; the joint nearest the head is yellow, the head is black, the thorax is also black, and encompassed round with a yellow line, and furnished with a cross one of the same colour, near the head. The scutellum is yellow, the abdomen black, with two yellow bands, and a spot of the same colour on each side between the bands. A deep black polished groove extends down the back, from the thorax to the anus, into which the sting turns and is deposited, leaving the anus very circular; a yellow line runs on each side

the sting. The anus and the whole body, when viewed with a shallow magnifier, appear punctuated; these points, when examined in the microscope, appear hexagonal, as in the plate; and in the center of each hexagon a small hair is to be seen; the feet are yellow, the hinder thighs very thick and toothed, and also form a groove for the next joint; they are yellow, with black spots: it is found in Italy, Switzerland, France, and Germany. Fig. 1, Plate XVII. shews it very much magnified. Fig. 2 is a side view of it less magnified. Fig. 3 is the object of its real size.

OF THE LOBSTER INSECT, DELINEATED FIG. 1 AND 6,
PLATE XVIII.

This extraordinary little creature was found by my ingenious friend, Mr. John Adams, of Edmonton; he was at the New Inn, Waltham Abbey, where it was spied by some labouring men who were drinking their porter. The man who first perceived it thought it was of an unusual form; this occasioned a nicer inspection, and it was supposed to be a louse with unusual long horns; others thought it was a mite. This occasioned a debate, which drew the attention of my friend, who obtained the insect from them for further observation. Mr. Martin has given some account of it in the third volume of "The Young Gentleman and Lady's Philosophy." Mr. Adams favoured me with the insect, that an accurate drawing might be taken from it, which I thought would be highly pleasing, not only to the lovers of microscopic observations, but also to the entomologist. It appears to be quite a distinct species from the phalangium cancroides of Linnaeus, of which a good drawing has been given by Hook,
Roefel,

Roefel, Schæffer, &c. it has also been described by Scopoli, Geoffroy, &c.; not one, however, of these descriptions agrees with the animal under consideration. The abdomen of this is more extended, the claws are larger and much more obtuse, the body of the other being nearly orbicular, the claws slender, and finishing almost in a point, more transparent, and of a paler colour. It is very probable that there are several species nearly similar. Mr. Marfham has two in his possession, one like the drawings of Reaumur, the other not to be distinguished from that which is represented in Plate XVIII. except that it wants the break, or dent, in the claws, which is so conspicuous in this. He found his firmly fixed by it's claws to the thighs of a large fly, which he caught on a flower in Essex the first week in August, and from which he could not disengage it without great difficulty, and tearing off the fly's leg, which he did on a piece of writing paper, and was much surprized to see the little creature spring forwards full a quarter of an inch, with great impetuosity, and again seize it's prey, from which he had great trouble to disengage it.

OF FIG. 3, 4, AND 5, PLATE XVIII.

The insect which is represented at Fig. 3, Plate XVIII. was originally named *physapus* by Mr. de Geer, on account of the bladders at the feet. Linnæus terms it *trips*.

They live upon plants, and particularly in flowers. The one figured here is the black trips, with white wings; the antennæ have six articulations, the body is black, the wings whitish, long and hairy, the head small, with two large reticular eyes. The

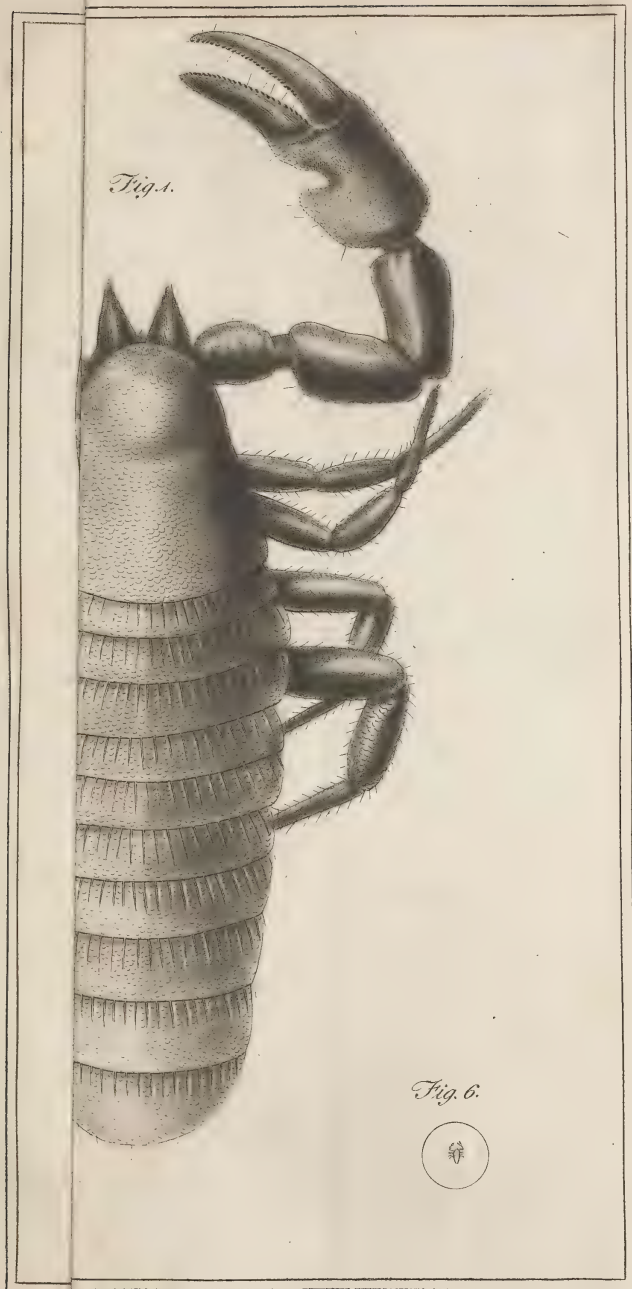
antennæ are of an equal size throughout, and divided into six oval pieces, which are articulated together. The extremities of the feet are furnished with a membranaceous and flexible bladder, which it can throw out or draw in at pleasure. It places and presses this bladder against the substances on which it is walking, and seems to fix itself thereby to them; the bladder sometimes appears concave towards the bottom, the concavity diminishing in proportion as it is less pressed.

They have four wings, two upper and two under ones; these last are with great difficulty perceived; they are fixed to the upper part of the breast, laying horizontally; both of them are rather pointed towards the edges, and have a strong nerve running round them, which is set with a hair fringe, tufted at the extremity. The wings are represented by themselves at Fig. 4; the insect of the real size at Fig. 5. They are to be found in great plenty in the spring and summer, in the flowers of the dandelion, &c.

OF FIG. 2, PLATE XVIII.

This beautiful opake object is a piece of the skin of the lump fish. For a full description of this singular creature, I must refer the reader to Pennant's British Zoology, vol. iv. page 117. There are no scales on the body, but a greater number of these tubercles, which are exhibited in this figure. When a good specimen is procured, it forms a most delightful object for the opake microscope. It is probable that the fish exudes an unctuous matter from these tubercles.

Fig.



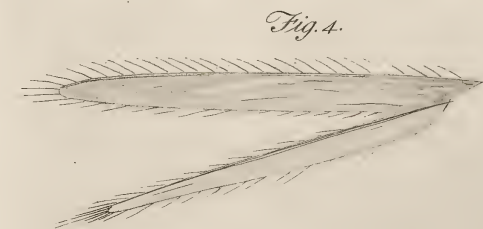


Fig. 6.





Fig. 1, Plate XX. is a beautiful insect of the hemiptera class, or that kind where the elytra are only in part crustaceous, and which do not form a longitudinal suture down the back, but fold over about one-third of their length towards the bottom, where it is also partly transparent. It is of the genus cimex, and called striatus by Linnæus. It cannot boast a variety of colours, though what it has are bright and elegantly disposed: the head, proboscis, and thorax, are black. The thorax is ornamented with yellow spots, the middle one large, and occupying almost one-third of the posterior part; the other two are on each side, and triangular. The scutellum has two yellow oblong spots, pointed at each end; the ground of the elytra is a bright yellow, spotted and striped with black. The nerves are yellow, and there is a brilliant triangular spot of orange, which unites the crustaceous and membranaceous parts; the latter is brown and clouded. The feet are of a fine red, and the rings of the abdomen are black, edged with white. This pretty insect is to be found in June, upon the elm-tree. It is represented at A of the natural size.

PLATE XX. FIG. 2.

A very common, though elegant, insect of the coleoptra class, is represented as seen in the lucernal microscope, and of it's natural size at B; it is called by Linnæus chrysomela asparagi, from the larva feeding on the leaves of that plant. It's figure is oblong, the antennæ black, composed of many joints nearly oval. The head is a bright but deep blue, the thorax red and cylindrical, the elytra blue, with a yellow margin, with three spots of the same colour on each, one at the base of an oblong form, and two united with the margin; the legs are black, but the under side of
the

the belly is of the same blue colour with the elytra and head. This little animal, when viewed by the naked eye, scarcely appears to deserve any notice; but when examined by the microscope, it is one of the most pleasing opaque objects we have.

This insect is found in June, on the asparagus after it has run to seed. De Geer says, that it is very scarce in Sweden.

FIG. 3, PLATE XX.

The insect which comes at present under our inspection is peculiarly adapted to shew the advantages of the microscope, which alone will discover the peculiarities of it's figure; this is so remarkable, that the naturalists appear undetermined as to it's genus. Geoffroy formed a new one for it, under the title of *notuxus*, in which he has been followed by Fabricius; even Linnaeus himself could not determine at first where to place it, for in the *Fauna Suecica* he makes it an *attelabus*, but in the last edition of the *Systema Naturæ* he has fixed it as a *meloe*, calling it the *meloe monoceros*; but still he adds, "*genus difficile determinatur forte huic proximum.*" Both Geoffroy and Schæffer have given figures of it, but as they had not that kind of microscope which would assist them, their figures are imperfect.

The head is black, and appears to be hid, or buried, under the thorax, which projects forwards like a horn; the antennæ are composed of many articulations, and with the feet are of a dirty yellow. The hinder part of the thorax is reddish, the fore-part black. The elytra are yellow, with a black longitudinal line down

Fig. 1.



Fig. 5.

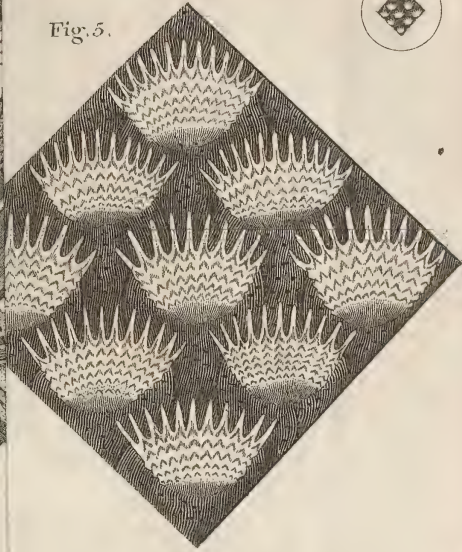


Fig. 6.



Fig. 7.

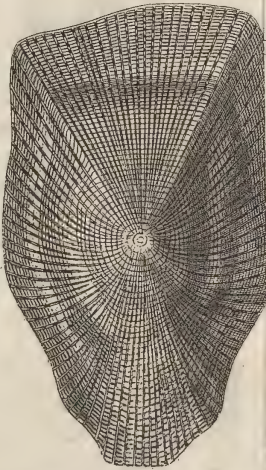
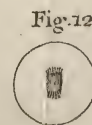
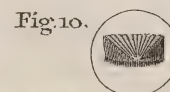
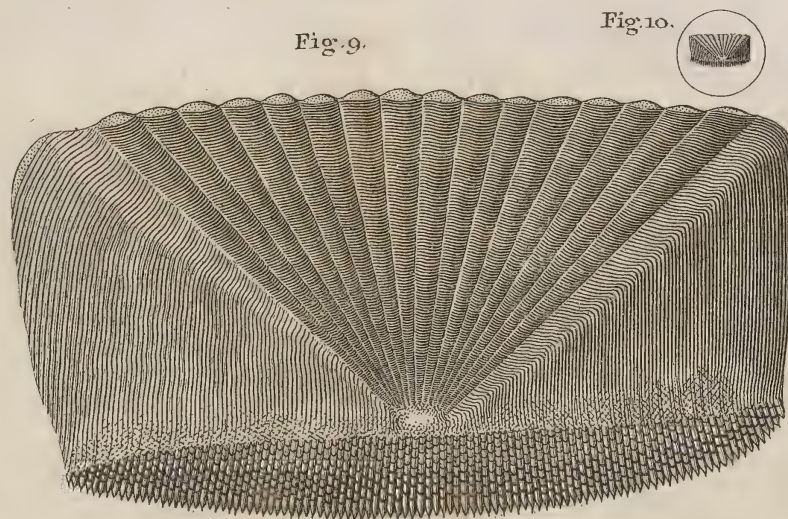
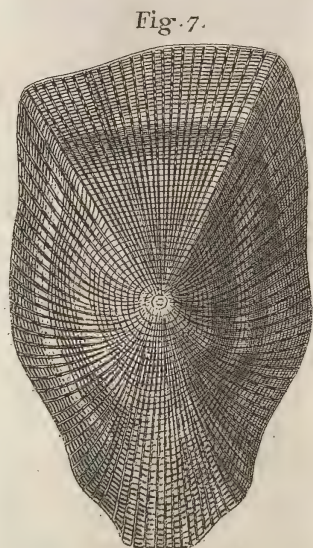
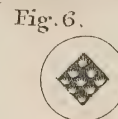
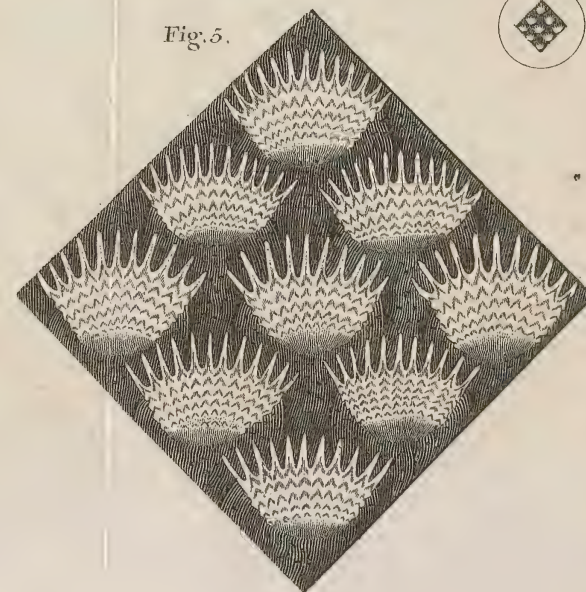


Fig. 11.



Fig. 12.





J. P. H. sc.

down the future; there is a band of the same colour near the apex, and also a black point near the base; the whole animal is curiously covered with hair. Geoffroy says it is found on umbelliferous plants; the one here described was found in May; the natural size is seen at C.

Fig. 1 and 3, Plate XIX. represents two of the feet of the *monoculus apus* of Linnæus. They are curiously contrived to assist the animal in swimming, and form a very beautiful object for the microscope.

Fig. 2 and 4 are of the natural size.

OF THE SCALES OF FISH.

The outside coverings, or scales, of fishes afford an immense variety of beautiful objects for the microscope. They are formed in the most admirable manner, and arranged with inconceivable beauty and regularity; some are of a long shape, others nearly round, some square, varying in shape, not only in different species of fish, but even considerably on the same fish; those which are taken from one part not being entirely similar to those which are taken from another.

Leeuwenhoeck supposed each scale to consist of an infinity of scales, laid one over the other, or more simply of an infinity of strata, of which those next the body of the fish are the largest.

These strata exhibit a specimen of very beautiful workmanship; when viewed with the microscope, we find them to be constructed
with

with wonderful art. In some scales we discover a prodigious number of concentric flutings, too fine, as well as too near each other, to be easily enumerated; they are probably formed by the edges of each stratum, denoting the limits thereof, and the different stages of the growth of the scale. These flutings are often traversed by others that proceed from the center of the scale, which is seldom in the middle thereof; these generally go in a straight line from this center to the circumference.

Fig. 7, Plate X. represents a scale from a species of the parrot fish of the West-Indies, considerably magnified. Fig. 8, the real size of the scale.

Fig. 9, Plate X. is a scale of the sea perch, which is found on the English coast.

Fig. 10, the same scale of the natural size.

Fig. 7, Plate XIX. a scale from the haddock, as seen in the microscope. Fig. 8, the same of the natural size.

Fig. 9, Plate XIX. a scale from a species of perch from the West-Indies, magnified. Fig. 10, the scale of its real size.

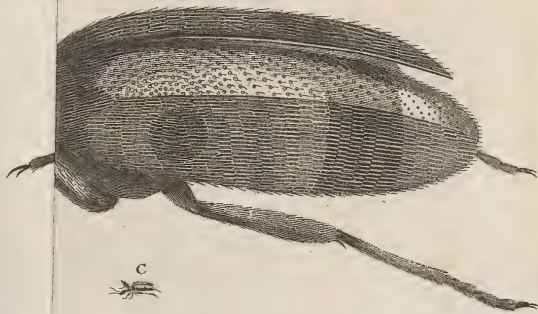
Fig. 11, a scale from the foal-fish, delineated as it appeared in the microscope; the pointed part is that which stands without the skin, as may be seen in Fig. 5, which represents a piece of the skin of the foal, as viewed by the opaque microscope. Fig. 6 and 12, the same objects of their real size.

C H A P.

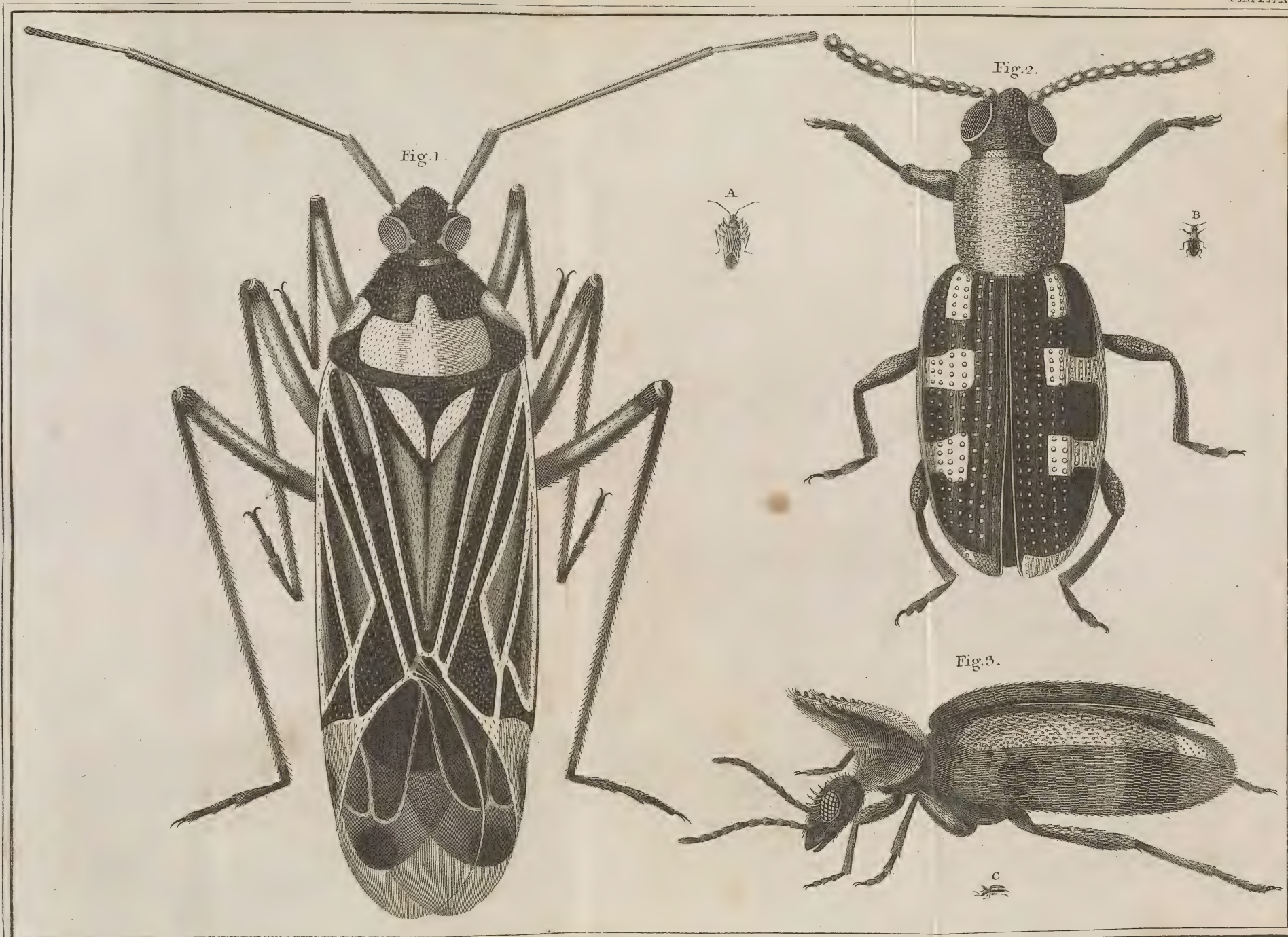
Fig. 2.



Fig. 3.



T. Blinn del.



V. M. del.

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J. Lodge sc.



C H A P. VII.

THE NATURAL HISTORY OF THE HYDRA, OR FRESH-WATER
POLYPE.

THE polypes described in this chapter are fresh-water insects, of the genus of hydra, in the class of worms, and order of zoophytes. When they are cut or divided into a number of pieces, the separated parts in a very little time become so many perfect and distinct animals; each piece having a power of producing a head, a tail, and the other organs necessary for its life and state.

They are generally known by the name of polype; but as this was thought by many to be improper, because that, strictly speaking, they have no feet, Linnæus called the genus hydra, probably from their property of reproducing the parts which are cut off, a circumstance that naturally brings to mind the fabulous story of the Lernean hydra. Dr. Hill called them biota, on account of the strong principle of life with which every part is endued.

Leeuwenhoeck, whose indefatigable industry in his researches after small insects permitted very few things to escape his notice,

3 B

discovered

discovered these animals, and gave some account of them in the Philosophical Transactions for the year 1703. There is also in the same volume a letter from an anonymous hand on this subject. We had, however, no regular account of them, their various habits, their different species, or of their wonderful properties, till the year 1740, when they first engaged the attention of Mr. Trembley, to whose assiduity and observations we are indebted for the knowledge of their nature and œconomy.

Before these discoveries of Mr. Trembley, Leibnitz and Boerhaave, by reflections on the various gradations in the scale of animated nature, had endeavoured to prove that there might be degrees of life between the animal and the plant, and that animals might be found which would propagate by slips, like plants. These conjectures were verified by Mr. Trembley, but not in consequence of any preconceived ideas in favour of such a supposition; on the contrary, it was only by repeated observations that he could destroy his own prejudices, and join these wonderful beings to the animal kingdom.

Though natural history is so fruitful in extraordinary facts, it has hitherto produced none so singular as the various properties of the different species of the hydra.

I shall endeavour, first, to trace the progress of this discovery, in which we shall see with what sage caution and accuracy Mr. Trembley, and other naturalists, examined this wonderful phenomenon, and what accumulated evidence was judged necessary to establish the facts.

We

We find Mr. Trembley writing in January, 1741, to Mr. Bonnet, that he did not know whether he should call the object which then engaged his attention a plant or an animal. "I have studied it, says he, ever since June last, and have found in it striking characteristics of both plant and animal. It is a little aquatic being. At first sight every one imagines it to be a plant; but if it be a plant, it is sensitive and ambulant; if it be an animal, it may be propagated by slips, or cuttings, like many plants." It was not till the month of March, in the same year, that he could satisfy himself as to their nature.

When Mr. Reaumur saw, for the first time, two polypes formed from one that he had divided into two parts, he could hardly believe his eyes; and even after having repeated the operation an hundred times, and again examined it an hundred more, he says, that the sight was not become familiar to him.

The first account the Royal Society received of the surprizing properties of this insect, was in a letter from M. Buffon (dated the 18th of July, 1741) to Martin Folkes, Esq. their president, acquainting them with the discovery of a small insect called a polypus, which is found sticking about the common duck-weed; and which, being cut in two, puts forth from the upper part a tail, and from the lower end a head, so as to become two animals instead of one. If it be cut into three parts, the middlemost puts out from one end a head, and from the other a tail, so as to become three distinct animals, all living like the first, and performing the various offices of their species: which observations are, adds M. Buffon, well averred.

There is no phænomenon in all natural history more astonishing than this, that man, at pleasure, should have a kind of creative power, and out of one life make two, each completely formed with all its apparatus and functions, each with its perceptions and powers of motion and self-preservation, each as complete in all respects as that from which it derived its existence, and equally enjoying the humble gratifications of its nature.*

Mr. Folkes, in confirmation of the foregoing article, communicated to the society a letter from C. Bentink, Esq. at the Hague, dated September, describing the insects discovered by Mr. Trembley, adding, that he himself had seen them. In November a letter was read from Dr. Gronovius, of Leyden, giving an account of a water insect, not yet known to or described by any author; after describing it, he adds, "but what is more surprizing, if this animal is cut into five or six pieces, in a few hours there will be as many animals, exactly similar to their parent." The accounts of this animal were so extraordinary, that they were not credited until Professors Albinus and Mussichenbrock were provided with animals, and found all that had been related thereof to be exactly true.

November 25, a letter from Cambridge was read at the Royal Society, in which the author endeavours to lessen, by reason, the prejudices which then combated the belief of these facts. "Some of our friends, says the author, who are firmly attached to the general metaphysical notions they have formerly learned, reason strongly

* Goldsmith's History of the Earth and Animated Nature.

strongly against the possibility of such a fact; but I have myself owned, on other occasions, my distrust of the truth, or certainty at least, of some of those principles, and I shall make no scruple of acknowledging, that I have already seen so many strange things in nature, that I am become very diffident of all general assertions, and very cautious in affirming what may or may not possibly be. The most common operations, both of the animal and vegetable world, are all in themselves astonishing, and nothing but daily experience and constant observation can make us see, without amazement, an animal bring forth another of the same kind, or a tree blossom and bear leaves and fruit.

“ The same observation and experience make it also familiar to us, that besides the first way of propagating vegetables from their respective fruit and seed, they are also propagated from cuttings, and every one knows that a twig of a willow particularly, cut off and only stuck into the ground, does presently take root and grow, and become as real and perfect a tree as the original one from which it was taken. Here then we find in the vegetable kingdom, quite common, the very thing of which we have an example before us in the animal kingdom, in this new-discovered insect. The best philosophers have long observed strong analogies between these two classes of beings; and the more they have penetrated into nature, the more they have extended this analogy: now in such a scale, who is the man that will be bold to say, just here animal life entirely ends, and here vegetable life begins? or, just so far, and no farther, one sort of operation goes; and just here another sort, quite different, takes its place? or again, who will venture to say, life in every animal is a thing absolutely different from that which we dignify by the same name

in every vegetable?" Thus does the author endeavour to persuade the prejudiced, and lead them to pay attention to the facts which were now laid open to their view, and which were further confirmed by a letter from Mr. Trembley, in January, 1740; which letter was strengthened by an extract from the preface to the sixth volume of Mr. de Reaumur's history of insects. In March, 1742, Mr. Folkes gave an account of them to the Royal Society, from observations made on several polypes which had been sent by Mr. Trembley from Holland to him. The insects now began to be known, and were soon found in England, and the experiments that had been made on them abroad were published by M. Folkes,* my father,† and Mr. Baker:‡ conviction now became too strong for argument, and metaphysical objections gave way to facts.

This animal is described in the following manner: §

H Y D R A.

Animal basi se affigens, vagum, gelatinosum, lineare nudum, contractile. Os terminale, cirrhis setaceis cinctum. Prolibus lateralibus (autumno ovīs) deciduis.

This animal fixes itself by it's base, it is gelatinous, linear naked, can contract itself, and change it's place. It's mouth, which

* Philosophical Transactions.

† Micrographia Illustrata.

‡ Natural History of the Polype.

§ Ellis's Nat. Hist. of Zoophytes, Lin. Syst. Nat. p. 1320.

which is at one end, is surrounded by hair, like feelers. It sends forth its young ones from its sides, which drop off; but in the autumn it produces eggs from its side.

1. *Hydra viridis, tentaculis subdenis brevioribus.*

Green polype, generally with about ten short arms; it is represented at Fig. 5, Plate XXI.

2. *Hydra fusca, tentaculis suboctonis longissimis.*

This polype has very long arms, often eight in number; it is represented at Plate XXI. Fig. 7. The arms are several times longer than the body.

3. *Hydra grisea, tentaculis subseptenis longioribus.*

This polype has also generally long arms, in number about seven; it is of a yellowish colour, small towards the bottom; it is represented at Fig. 6, Plate XXI.

4. *Hydra pallens, tentaculis subsenis mediocribus.*

The arms of this polype are generally about six in number, and of a moderate length.

5. *Hydra hydatula, tentaculis quaternis obsoletis corpore vesicario, Fig. 1, 2, 3, 4, Plate XXI.*

This

This polype has a vesicular body, and four obsolete arms; is found in the abdomen of sheep, swine, &c.

6. *Hydra stentorea*, tentaculis ciliaribus corpore infundibuliformi.

This polype has been called tunnel shaped; the mouth is furnished with a row of hairs; it is represented at Fig. 27 and 28, Plate XXII.

7. *Hydra socialis mutica torosa rugosa*.

Bearded thick and wrinkled, Fig. 11, Plate XXI.

OF THE *HYDRA VIRIDIS*, *HYDRA FUSCA*, AND *HYDRA* *GRISEA*.

These three species of the hydra having been those on which the greatest number of experiments have been made, and of which we have the best information, it is of these only we shall speak in the following account, unless we give particular notice thereof to the reader.

There are few animals more difficult to describe than the hydra, as it has scarce any thing constant in it's form, varying continually in it's figure; they are often so beset with young, as to appear ramose and divaricated, the young ones constituting as it were a part of the parent's body.

Whoever

Whoever has looked with care at the bottom of a wet shallow ditch, when the water is stagnant, and the sun has been powerful, may remember to have seen many little transparent lumps, of a jelly-like appearance, about the size of a pea, and flattened on one side; the same appearances are also often to be seen on the under side of the leaves of those weeds, or plants, that grow on the surface of the water; these are the hydra, gathered up into a quiescent state, and seemingly inanimate, because either undisturbed, or not excited by the calls of appetite to action. They are generally fixed by one end to some solid substance, at the other end there is a large opening, round about which the arms are placed as so many rays round a center, which center is the mouth.

They are slender and pellucid, formed of a kind of tender substance, in consistence something like the horns of a snail, and can contract the body into a very small compass, or extend it to a considerable length. They can do the same with the arms; with these they seize minute worms and various kinds of aquatic insects, bring them to the mouth and swallow them. After the food is digested, and the nutritive parts which are employed in sustaining its life are separated from the rest, they reject the remainder by the mouth.

The first polype which Mr. Trembley discovered was one of the hydra viridis, represented at Fig. 5, Plate XXI. These are generally of a fine green colour. The indications of spontaneous motion were first perceived in the arms of these little creatures; they can extend or contract, bend and wind them divers ways. Upon the slightest touch they contract themselves so much, as to appear little more than a grain, of a green substance, the arms

disappearing entirely. He soon after found the hydra grisea, Fig. 6, and saw it eat, swallow, and digest worms much larger than itself. This discovery was soon followed by that of the hydra fusca, Fig. 7, Plate XXI.

The most general attitudes of these hydræ are those which are represented in Fig. 5 and 6, Plate XXI. They fix the posterior extremity *b* against a plant, or other substance, as *ef*; the body *ab*, and the arms *ac*, being extended in the water. There is a small difference in the attitudes of the three kinds which we are now describing.

The bodies of the hydra viridis, Fig. 5, and of the hydra grisea, Fig. 6, diminish from the anterior to the posterior extremity by an almost insensible gradation. The hydra fusca does not diminish in the same gradual manner; but from the anterior extremity *a* to the part *d*, which is often two-thirds of the length of their body, it is nearly of an equal size; from this part it becomes abruptly smaller, and goes on from thence of a regular size to the end. The number of arms in these three kinds are at least six, and at most twelve or thirteen, though eighteen may sometimes be found on the hydra grisea. They can contract their bodies till they are not above one-tenth of an inch in length; they can also stop at any intermediate degree, either of contraction or extension, from the greatest to the least. The species represented at Fig. 5 are generally about half an inch long when stretched out. Those exhibited at Fig. 6 and 7 are about three-fourths of an inch, or one inch, in length, though some are to be found at times about an inch and an half long. The arms of the hydra viridis, Fig. 5, are seldom longer than their bodies;
those

those of Fig. 6 are commonly one inch long, while those of Fig. 7 are generally about eight inches; whence Mr. Trembley has called it the long-armed polype.

The bulk of the hydræ decreases in proportion as they extend themselves, and vice versa. They may be made to contract themselves, either by touching them, or agitating the water in which they are contained. They all contract themselves so much when taken out of the water, as to appear only like a little lump of jelly. They can contract or extend their arms without extending or contracting the body, or the body without making any alteration in the arms: or they can contract or dilate only some of the arms, independent of the rest: they can also bend their body and arms in all possible directions. Those represented at Fig. 7, let their arms in general hang down, making different turns and returns, often directing some of them back again to the top of the water. They can also dilate the body at different places, sometimes at one part, and then again at another; sometimes they are thick set with folds, which, if carelessly viewed, might be taken for rings.

They have a progressive motion, which is performed by that power by which they stretch out, contract, and turn themselves every way. For suppose the hydra, or polype, *a b*, Fig. 16, Plate XXI. to be fixed by the tail *b*, having the body and arms *a* extended in the water, in order to advance, it draws itself together, by bending itself so as to bring the head and arms down to the substance on which it is to move; to do this, it fixes the head, or the arms, as in Fig. 17; when these are well fixed, it loosens the tail, and draws it towards the head, as in Fig. 18,

which it again loofens, and refitting on the tail, fretches it out, as in Fig. 19. It is easy to fee from this account, that their manner of walking is very analogous to that of various terrestrial and aquatic animals. They walk very flow, often stopping in the middle of a step, turning and winding their body and arms every way. Their step is sometimes very fingular, as in the following instance: fuppofe the polype *a b*, Fig. 20, to be fixed by the tail *b*, the body and arms being extended in the water, it firft bends the fore-part towards the fubftance on which it is moving, and fixes it thereto as at *a*, Fig. 21; it then loofens the lower end, and raifes it up perpendicular, as in Fig. 22; now bending the body to the other fide, it fixes the tail as in Fig. 23; then loofening the anterior end, it rifes up, as in Fig. 24.

They defcend at pleafure to the bottom of the water, and afcend again, either by the fides, or upon fome aquatic plants; they often hang from the furface of the water, refitting as it were upon the tail; at other times they are fufpended by one arm from it. They walk alfo with eafe upon the furface of the water. If the extremity of the tail *b*, Fig. 7, be examined with a magnifying glafs, a fmall part of it will be found to be dry, and above the furface of the water, and as it were in a little concave fpace, of which the tail forms the bottom, fo that it feems to be fufpended on the furface of the water, on the fame principle that a fmall pin, or needle, is made to fwim.

Hence when a polype means to pafs from the fides of the glafs to the furface of the water, it has only to put that part out of the water by which it means to be fupported, and give it time to dry, which it always does upon thefe occafions. They attach them-

selves so firmly by the tail to aquatic plants, stones, &c. as not to be easily driven from the place where they have fixed themselves; they often further strengthen these attachments, by means of one or two of their arms, which they throw out and fix to adjacent substances as so many anchors.

The mouth of the polype, or hydra, is situated at the fore-part of the body, in the middle between the shooting forth of the arms. The mouth assumes different appearances, according to the different purposes of the insect; sometimes it is lengthened out, and forms a little conical nipple, as at Fig. 13, Plate XXIII. A; sometimes it appears truncated, as at Fig. 8, Plate XXI; at other times the interval between the arms appears closed, as at Fig. 2 and 12, Plate XXIII. A; or hollow, as at Fig. 11, Plate XXIII. A. If it is observed with a deep magnifier, in either of the two last cases, a small aperture may be discovered.

The mouth of the polype opens into the stomach, which is a kind of bag, or gut, that goes from head to tail; this may be perceived by the naked eye, when they are exposed to a strong light, or a candle placed on the opposite side to the eye; for the colour of the polype does not destroy the transparency thereof. The stomach will, however, be better seen, if the eye be assisted by a deep magnifier; one of them is represented as highly magnified, at Fig. 8, Plate XXI. To be fully satisfied whether they were perforated throughout, Mr. Trembley cut one transversely into three parts; each piece immediately contracted itself, and became very short, and being placed in a shallow glass full of water, and viewed through the microscope, they were found to be visibly perforated. They are represented as they appear in the microscope,

scope, at Fig. 6, 7, 8, Plate XXIII. A; it's mouth was at the anterior end *a*, Fig. 8, of one of these parts. The tail was at the end *b* of the third part, Fig. 6; as this piece was also perforated, it plainly appears, that the tail of the hydra is open. The perforation, which is thus continued from one end to the other, is called the stomach, because it contains and digests the aliments. The skin which incloses the bag, and forms the stomach, is the skin of the polype itself; so that the animal may be said to consist of but one skin, disposed in the form of a tube, or gut, open at both ends. On opening the polype, no vessels are to be distinguished; and whatever be the nature of it's organization, it must reside in the skin.

The skin must be so far organized, as to perform all the operations necessary for the nutrition and growth of the animal, without considering those that are necessary for it's various motions. Whatever are the means the Author of nature has employed for these purposes, we are ignorant of them. If their skin is examined by a microscope, it appears like shagreen, or as if it were covered with little grains; these are more or less separated from each other, according to the degree in which the body is extended or contracted.

If the lips of a polype be cut transversely, and placed so that the cut part of the skin may lie directly before the microscope, the skin throughout it's whole thickness will be found to consist of an infinite number of these grains. To know whether the inside of the stomach was formed of similar grains, several of them have been laid open and examined by the microscope; the interior surface was then found to consist of an immense number of them,

them, being as it were more shagreened than the exterior one, and less transparent. The grains are not strongly united to each other, but may be separated without much trouble. Fig. 10, Plate XXIII. A, represents a piece of skin thus laid open. To examine these particulars further, a piece of skin a, Fig. 9, was laid in a few drops of water, on a piece of glass, before the microscope, and some of the grains were separated from it, as at b c d, by pressing them with the point of a pin; in endeavouring to open them, they spread themselves into all parts of the water, and at last remained in heaps, as at e and f.

If a polype is carefully placed before the microscope, without wounding it, you will seldom be disappointed in seeing some of these grains detach themselves from the superficies thereof, and that even in the most healthy.

But if the grains separate themselves in large quantities, it is the symptom of a very dangerous disorder; the surface of the polype thus attached becomes more and more irregular, and is no longer well terminated and defined as before. The grains fall off on all sides, the body and arms contract and dilate, it becomes of a white shining colour, loses its form as at a, Fig. 4, Plate XXIII. A, and then dissolving into a heap of grains, as at b, Fig. 5. The progress of this disorder is most easily observed in the *hydra viridis*.

A very attentive and accurate examination shews that the skin is formed of a kind of glarous substance, a species of gum, which fills up the intervals between the grains, in which they are lodged, and by which they are attached (though weakly) together.

It

It has been already observed, that it is to these grains that it owes it's shagreen-like appearance; it is from them also that it derives it's colour; for when they are separated from the polype, they are the same colour with it; whereas the glarous matter is without any distinguishing colour. The construction of the polype seems then to be confined to these glandular grains, to the viscous matter, and the invisible fibres which act upon the glarous substance.

The structure of the arms of the polypes are very analogous to that of their body. When they are examined by the microscope, either in a contracted or dilated state, their surface is shagreened; if the arm be much contracted, it appears more so than the body; on the contrary, it appears less so in proportion as they are more extended, almost quite smooth when at their full extension; so that in the hydra viridis the appearance of the arms is continually varying, and these variations are more sensible towards the extremity of the arm than at it's origin, as at Fig. 10, Plate XXI. but more thinly scattered, or farther asunder, in the parts further on, as at Fig. 9, Plate XXI. The extremity is often terminated by a knob, the hairs which are exhibited in Fig. 9, cannot be seen without a very deep magnifier, however they indicate a further degree of organization in this little animal.

All animals of this kind have a remarkable attachment to turn towards the light, and this might naturally induce the inquirer to look for their eyes; but how carefully soever this search has been pursued, and however excellent the microscope with which every part has been examined, yet no appearance of this organ was found. Notwithstanding this, they constantly turn themselves towards the light; so that if that part of the glass in which we placed

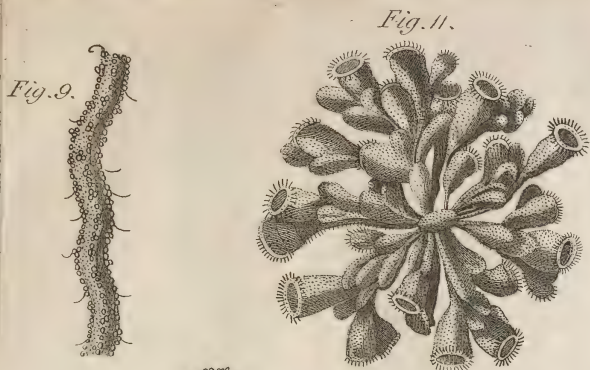


Fig. 14.

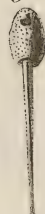


Fig. 15.



Fig. 16.

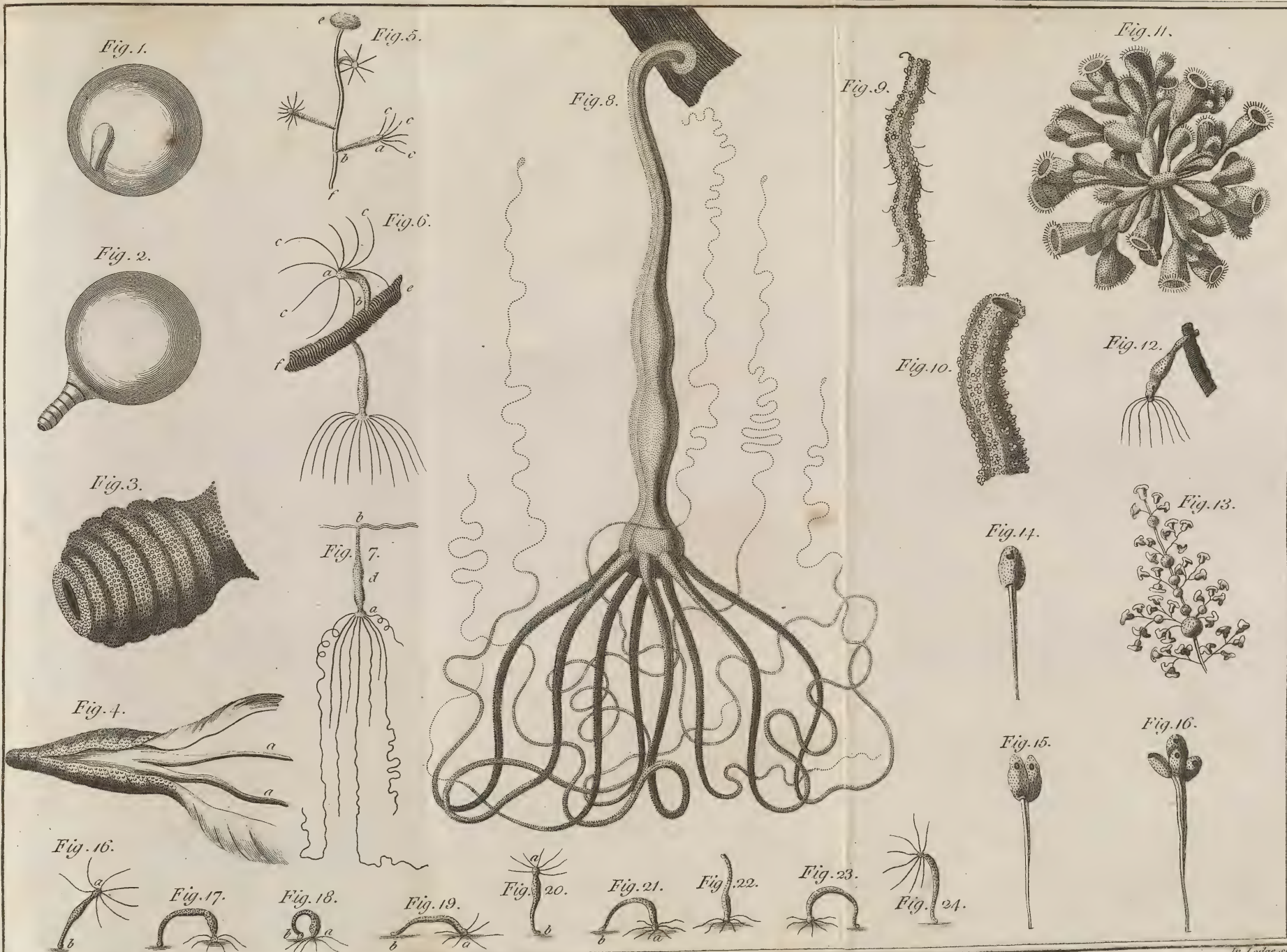


3.



Insects. May 20. 1787.

Jm. Lodge sc.



M. Lodge sc.



placed them be turned from it, they will be found the next day to have removed themselves to the side that is next the light, and the dark side will be quite depopulated.

OF THE FOOD OF THE HYDRÆ, AND THEIR METHOD OF
SEIZING AND SWALLOWING THEIR PREY.

As the hydra fusca, Fig. 7, Pl. XXI. has the longest arms, it's manner of feeding, and the different manœuvres it makes use of to seize and manage it's prey, are more remarkable than those of the two other species; it will be, therefore, this kind only which will be principally spoken of under the present head. To view them properly, they should be placed in a glass seven or eight inches deep. If the polype is fixed near the top of the glass, their arms for the most part hang down towards the bottom. This is a very convenient situation for giving them their food, and to observe how they manage it.

An hungry polype spreads it's arms as a fisherman his nets; it extends them every way, so that they form a circle of considerable extent, every part of which is entirely within the reach of one of them; in this expanded posture it lies in expectation of it's food; whatever comes within the verge of this circle is seized by one or another of it's arms. The arms are then contracted till the prey is brought to the mouth, when it is soon devoured. While the arms are contracting, and exerted vigorously, (to counteract the efforts the animal which it has seized makes in order to escape) they may be observed to swell like the muscles of the human body when they are in a state of exertion.

The polype does not always wait for it's prey, it feels for it, and in a manner follows it. It may be asked, how can it do this when it has no eyes? or, do the glandular grains answer this purpose? Who can answer the question? what are our own eyes but glandular grains of a larger size? If this should be the case, our hydra would again exceed and realize the fables of the ancients, being an argus entirely composed of eyes. Be this as it may, they are certainly in possession of some sentiment by which they can perceive the approach of their prey, and which renders them attentive to all that may confirm or destroy this perception.

When the arms of a polype are extended, put a millepedes, or any kind of worm, into a glass, (see Fig. 1, Pl. XXIV. A) and with the point of a pencil push it towards one of the arms; as soon as it touches this it is seized; the worm, or millepedes, endeavours by quick and strong efforts to disengage itself, often swimming and dragging the arm from one side of the glass to the other. This violent motion of the prey obliges the polype to contract strongly the arm, in doing which it often twists it in the form of a corkscrew, as at o i, by which means it shortens it more rapidly; the struggles of the devoted animal soon bring it in contact with another arm, these contracting further, the little creature is presently engaged with all the arms, which contract so much as to convey it to the mouth, against which it is held and subdued.

When a polype has nothing to eat, it's mouth is generally open, but so small that it can scarce be perceived without the assistance of a magnifying glass; but as soon as the arms have conveyed the prey to the mouth, it opens itself wider, and this in proportion to the size of the animal that is to be devoured; the

lips gradually dilate, and adjust themselves accurately to the figure of the prey. The greatest part of the animals on which the polype feeds, are to it's mouth what an apple, the size of our heads, would be to the mouth of a man.

The worms, &c. which are seized by the polype are not always brought to the mouth in the same situation; if they are presented to it by one of their extremities, it is not requisite that the polype should open it's mouth considerably, and in effect it only opens it so wide, as precisely to give entrance to the worm, Fig. 5, Plate XXIV. A. If it be not too long for the stomach, it remains there extended; but if it be longer, the end which first enters is bent, so that when the worm is entirely swallowed, it may be seen lying folded in the stomach, Fig. 12, Plate XXIV. B.

If the middle, or any other part of the worm, be presented to the mouth of the polype, it seizes this part with the lips, extending them on both sides, and applying them against the worm, so that the mouth assumes the form of a boat, pointed at each end, Fig. 2, Plate XXIV. A; the polype gradually closes the two points of it's boat-like lips, and by this motion and suction swallows the worm, Fig. 4, Plate XXIV. A.

A worm is killed so soon by a polype, that Mr. Fontana thinks they must contain the most active and powerful venom; for it's lips scarce touch the worm but it expires, so great is the energy of the poison it conveys into it, though no wound can be observed in the dead animal.

As soon as the stomach is filled, it's capacity is enlarged, the body is shortened, Fig. 6, Plate XXIV. A, the arms are for the most part contracted, the polype hangs down without motion, and appears to be in a kind of stupor, and very different from it's extended shape; but in proportion as the food is digested, and it has voided the excrementitious parts, the body lengthens, and gradually recovers it's form.

The transparency of the polype permits us to see distinctly the worm which has been swallowed, Fig. 12, Plate XXIV. B, which gradually loses it's form. It is at first macerated in the stomach of the polype, and when the nutritious juices are separated from it, the remainder is discharged by the mouth, Fig. 13. It is with these as with other voracious animals, as they eat a great deal at once, so also they can fast for a long time. The history of insects furnishes many examples of this kind.

One circumstance is observable, which probably contributes much to the digestion of their food, namely, that the aliments are continually pushed back from one extremity to the other of the stomach; this motion may be easily observed with a microscope, in a polype which is not too full, and in which the food has been already divided into little fragments. For these observations, it is best to feed the polype with such food as will give a lively-coloured juice; as for example, those worms whose intestines are filled with red substances: for by this means we shall see that the nutritious juices are conveyed not only to the extremity of the body, but also into the arms, from whence it is probable that each of the arms form also a kind of gut, which communicates with that of the body. Some bits of a small black snail, that is frequently

frequently to be found in our ditches, was given to a polype. The substance of this skin was soon reduced into a pulp, consisting of little black fragments; on examining the polype with the microscope, these particles were perceived to be driven about the stomach, and to pass from head to tail, and into their arms, even where these were as fine as a thread; they were afterwards forced into the stomach, and from thence to the tail, from whence they were again driven into the arms, and so on.

The grains take their tinge from the food which nourishes the polypes; these grains become red or black, if the polype be fed with juices that are either red or black; and they are more or less tinged with these different colours, in proportion to the strength and quantity of the nutritive juices. It is also observable, that they lose their colour if fed with aliments that are not of the same colour with themselves.

The polypes feed on the greater part of those insects that are to be found in fresh water. They may be nourished with worms, the larva of gnats, &c. they will also eat larger animals if they are cut into small pieces, as snails, large aquatic insects, small fish, butchers meat, &c. Sometimes two polypes seize the same worm, and each begins to swallow it's own end, continuing so to do till their mouths meet, Fig. 8, Plate XXIV. A; in this position they remain for some time; at last the worm breaks, and each has it's share; sometimes the combat does not end here, for each continuing to dispute the prize, one of the polypes opens it's mouth advantageously, and swallows the other with it's portion of the worm, see Fig. 14, Plate XXIV. A; this combat ends more fortunately for the devoured polype than might be at first expected,

pected, for the other often gets the prey out of it's stomach, but lets it out again sound and safe, after having imprisoned it above an hour. From hence we learn, that the stomach of the polype, which so soon dissolves the animal substances which are conveyed into it, is not capable of digesting that of another polype.

Fig. 5, Plate XXIV. A, represents a polype with one-half of a millipedes in it's mouth, as at a; the other part without as at m. Fig. 1, Plate XXIV. A, represents one suspended in water by a piece of packthread; c n, a millipedes seized by it, and drawn partly towards the mouth; i o the bendings in the arm; p an arm in search of a small aquatic insect. Fig. 2, Plate XXIV. A, a polype stretching itself into a boat-like form, to take or swallow a worm lying sideways. Fig. 4, Plate XXIV. A, the same polype, with the worm swallowed and bent within it. Fig. 6, the same plate is a polype in the situation they generally assume when they have satisfied their voracious appetite. Fig. 7, one that has swallowed a small monocolus. a, Fig. 9, one whose arms are loaded with monocoli. Fig. 10, a polype full of them from head to tail. Fig. 3, one that has only swallowed a few of them.

In this paragraph I shall speak of some of the figures contained in Plate XXIV. B. Fig. 12, a worm seen within the skin of a polype. Fig. 13, disgorging the excrementitious parts thereof. Fig. 11 represents one engaged with a very large worm.

Fig. 8, Plate XXIV. A, represents two polypes engaged in combat for a worm, of which both of them have swallowed a part.

Fig.

Fig. 12, Plate XXI. a polype that has swallowed a small fish, and taken the shape thereof.

OF THE GENERATION OF THE HYDRÆ.

As the *hydra fusca* and the *hydra grisea* are considerably larger than the *hydra viridis*, it is more easy to observe the manner of their producing their young. It is upon these, therefore, that most of the observations here recited have been made. If one of them be examined in summer, when the animals are most active and more particularly prepared for propagation, it will be found to burgeon forth from it's sides several little tubercles, or knobs, which grow larger and larger every day; after two or three days inspection, what at first appeared but a small excrescence, takes the figure of a small animal, entirely resembling it's parent.

When a young polype first begins to shoot, the excrescence terminates in a point as at e, Fig. 24, Plate XXIV. B, so that it is rather of a conical figure, and of a deeper colour than that of the body. This cone soon becomes truncated, and in a little time appears cylindrical. The arms then begin to shoot from the anterior end c i, Fig. 24, Plate XXIV. B. The tail adheres to the body of the parent, but grows gradually smaller, till at last it only adheres by a point b, Fig. 23, Plate XXIV. B; it is then ready to be separated; for this purpose the mother and young ones fix themselves to the glass, or other substance upon which they may be situated. They have then only to give a sudden jerk, and they are divided from each other. There are some trifling differences to be observed now and then in their performing this operation, which it would be too tedious to enumerate here.

here. A polype, a b, Fig. 26, with a young one, c d, places it's body in an arch of a circle a d b, against the sides of the glass, the young one being fixed at the top d of the arch, with it's head also fixed against the glass; so that the mother, by contracting the body, and thus becoming strait, loosens herself from the young one.

The young ones shoot in proportion to the warmth of the weather, and the nature of the food eaten by the mother; some have been observed to be perfectly formed in twenty-four hours, while others have required fifteen days for the same purpose; the first were produced in the midst of summer, the latter in a cold season.

The tail of the young polype communicates with and partakes of the food from the parent in the same manner as it's own arms do, and the food lies in the same manner as in the arms. When this foetus is furnished with arms, it catches it's prey, swallows, digests, and distributes the juices thereof, even to the parent body; every good is common to each. Here then we have evident communication between the foetus and the mother; this communication was further proved by the following experiment. A large polype (one of the *hydra fufca*) was placed on a slip of paper, in a little water; the middle of the body of the young one was cut, and the superior part of that end which remained fixed to the parent was found to be open. The parent polype was then cut on each side of the shoot. Thus a short cylinder was obtained, which was open at both ends. This being viewed through a microscope, the light was seen to come through the side slip, or young one, into the stomach of the old one. For further conviction, the cylindrical

cal portion was cut lengthways; on observing these parts, not only the hole *t* of communication, Fig. 17, Plate XXIV. B, was distinctly seen, but one might see through the end *o* of the young one. On changing the situation of these two pieces of prepared polypi, and looking through the opening *e*, Fig. 18, the daylight was seen through the hole of communication *i*.

This communication between the parent polype and it's young ones may be seen on feeding them; for after the parent, *a b*, Fig. 22, Plate XXIV. B, has eaten, the body of the young ones swell, being filled with the aliments as if they themselves had been eating. In the *hydra fusca* the young ones do not proceed from the tail part *b c*, Fig. 16, Plate XXIII. B, but only from the part *a c*, with this exception, there is no particular part of the body before the rest, on which they produce their young. Some of them have been so closely observed, and have so greatly multiplied, that there would be scarce any impropriety in saying they produced their young ones from all the exterior parts of the body. A polype puts forth often five or six young ones at the same time. Mr. Trembley has had some that have produced nine or ten at the same time, and when one dropped off another came in it's place.

Though Mr. Trembley had for two years thousands of them under his eye, and considered them with the most scrupulous attention, he never observed any thing like copulation. To be more certain on this head, he took two young ones the instant they came from their parent, and placed them in separate glasses; they both multiplied, not only themselves, but their offspring, which were separated and watched in the same manner to the

seventh generation; nay, they have even the faculty of multiplying while they adhere to the parent. The arms of the young ones do not sprout till the body has attained some length.

Several excrescencies, or buds, often appear at the same time on a polype, which are so many polypes growing from one trunk; whilst these are developing, they also bud, which buds again put forth little ones, the parent and the young ones forming a singular kind of animal society, in which all participate of the same life, and the same wants. In this state the parent appears like a shrub, thick set with branches. Several generations are often thus attached to one another, and all to the parent polype; after a time, this tree of polypes, or hydræ, is decomposed, and gives birth to new generations, or fresh genealogical trees. Here we see a surprizing chain of existence continued, and numbers of animals naturally produced, without any union of sexes.

From Fig. 16, Plate XXIII. B, the reader may form an idea of the promptitude with which these creatures increase and multiply; the whole group formed by the parent and it's young was about an inch and an half long, and one inch broad; the arms of the mother and her nineteen little ones hanging down towards the bottom of the vessel; the animal would eat about twelve monoculars per day, and the little ones about twenty among them, or rather more than thirty for the groupe.

OF THE RE-PRODUCTION OF POLYPES.

A polype cut transversely, or longitudinally, in two or three parts, is not destroyed, each part in a little time becomes a perfect

perfect polype. This species of fecundity is so great in these animals, that even a small portion of their skin will become a little polype, a new animal rising as it were from the ruins of the old, each small fragment yielding a polype. If the young ones are mutilated while they grow upon the parent, the mutilated parts are re-produced; the same changes succeed also in the parent. A truncated portion will put forth young before it is perfectly formed itself, or has acquired it's new head and tail; sometimes the head of the young one supplies the place of that which would grow out of the anterior part of the trunk.

If a polype is slit, beginning at the head, and proceeding to the middle of the body, a polype will be formed with two heads, and will eat at the same time with both. If the polype is slit into six or seven parts, it becomes a hydra, with six or seven heads. If these are again divided, we shall have one with fourteen; cut off these, and as many new ones will spring up in their place, and the heads thus cut off will become new polypes, of which so many new hydras may again be formed; so that in every respect it exceeds the fabulous relation of the Lernean hydra.

As if the wonders already related of the polype were not sufficient to engage our attention to these singular animals, new circumstances, as surprizing as the foregoing, present themselves to convince us of the imperfection of our ideas of animality, and of the greatness of the power of our Lord and Saviour, who is the source and origin of every degree of life, in all it's immense gradations, as unity is the origin of number, in all it's varied series, multiplied proportions and combinations; now as numbers may be considered as being recipient of unity, in order to make

manifest the wonderful powers thereof, so the universe and its parts are adapted to receive life from the source of all life, and thus become representatives of his immensity and eternity.

The polypes may be as it were grafted together. If the truncated portions of a polype are placed end to end, and then pushed together with a gentle force, they will unite, and form a single one. The union is at first made by a fine thread, and the portions are distinguished by a narrow neck, which gradually fills up and disappears, the food passing from one portion to another. Portions, not only of the same, but pieces of different polypes, may be thus united together. You may fix the head of one polype to the trunk of another. And that which is thus produced will grow, eat, and multiply like another.

There is still another method of uniting these animals together, more wonderful in its nature, and less analogous to any known principles of animation, and more difficult to perform. It is effected by introducing one within the other, forcing the body of one into the mouth of the other, and pushing it down so that their heads may be brought together; in this state it must be kept for some time; the two individuals are at last united, and grafted into each other; and the polype, which was at first double, is converted into one, with a large quantity of arms, and performs all its functions, like another.

The hydra fusca furnishes us with another prodigy, to which we know nothing that is similar, either in the animal or vegetable kingdom. They may be turned inside out like a glove, and
notwith-

notwithstanding the apparent improbability of the circumstance, they live and act as before. The lining, or coating, of the stomach now forms the epidermis, and the former epidermis now constitutes the coating of the stomach. A polype thus turned may often have young ones attached to its side. If this is the case, after the operation they are of course inclosed in the stomach. Those which have acquired a certain size extend themselves towards the mouth, that they may get out when separated from the body; those which are but little grown turn themselves inside out, and by this means place themselves again on the outside of the parent polype.

The polype thus turned, combines itself a thousand different ways. The fore-part often closes itself, and becomes a supernumerary tail. The polype which was at first strait, now bends itself, so that the two tails resemble the legs of a pair of compasses, which it can open and shut. The old mouth is at the joint as it were of the compasses; it cannot, however, act as one, so that a new one is formed near it, and in a little time you have a new species of hydra with several mouths.

Fig. 18, Plate XXIII. B, represents the upper part of a polype that has been divided into two parts, a the upper, c the lower part, the end c being something larger than that of a common polype, and is sensibly perforated; in the summer time this part often walks and eats the same day it is cut.

Fig. 17, the other part of the same polype; the anterior end is very open, and the edges of it turned a little outwards, which afterwards folding inwards, close the aperture. This end
now

now appears swelled, as at c, Fig. 21; the arms shoot out from this end; at first three or four points only begin to shoot, as at c, Fig. 20, and while these increase in size, others appear between them; they can seize their prey, and eat before their arms have done growing. In the height of summer, the arms will often begin to shoot in twenty-four hours; but in cold weather it will be fifteen or twenty days before the head is formed.

Fig. 22 represents a polype that was cut close under the arms; this became also a complete animal in a little time.

The fides of a polype, that has been cut longitudinally, roll themselves up in different ways, generally beginning at one of the extremities, rolling itself up in a heap, as at Fig. 19, Plate XXIII. B, with the outside of the skin inwards; it soon unrolls itself, and the cut fides form themselves into a tube, whereof the edges a b and e i, Fig. 15, on both fides, meet each other and unite. Sometimes they begin to join at the tail end, at other times the whole fides gradually approach each other. The fides join so close, that from the first moment of their junction no scar can be discovered.

Fig. 14, Plate XXIII. B, represents a polype partly joined, as at i b, the part c a e not yet closed.

Fig. 29, Plate XXIII. B, represents a polype, the heads of which have been repeatedly divided, by which means it becomes literally a hydra.

Fig. 24 represents a polype that had been turned, endeavouring to turn itself back again, the skin of the anterior part lying back upon the other; the arms varying in their direction, being sometimes turned towards the head, see Fig. 24 and 26, Plate XXIII. B, at others towards the tail. The anterior extremity c, formed by the edges of the reversed part a, remained open for some days, and then began to close, new arms shot out near the old ones, and several mouths were formed at those parts where the arms joined the body.

Fig. 23, 25, 27, 28, represent the different changes that took place in another polype that had been turned inside out, and the different revolutions it went through before it acquired a fixed state. a c always shews the part the polype had turned back, and a b the part it could not turn back.

A polype, which has been partly turned back, remains but a little time in that situation. a, Fig. 28, Plate XXIII. B, the part where the portion it had turned back joined to the body a b; this became strait, and formed a right angle with a b; the same day another head appeared at c, and several arms, a o a n, began to shoot from the mouth a; at the other side of this mouth there were the old arms a d. The next day the portion a c was drawn near the body, and formed an acute angle with it, as at Fig. 25. Fig. 27 represents the same swelled, after having swallowed a worm. Four days afterwards its form had varied considerably, as may be seen by comparing Fig. 25 and 28, having now one common mouth and two small polypes growing on it.

We may now be permitted to make a few reflections on this singular animal. On considering the various properties that have been already described, we shall find in them many particulars, that are very analogous to others that are continually carrying on around us; we perceive that there is a successive unfolding of new parts. In every organized frame there is a continual effort to extend it's sphere of action, and enlarge the operation of that portion of life which is communicated to it. This gradual evolution requires a secret and curious mechanism to regulate and modify by re-action the continued conatus of the forming principle within it. The polype is an organized whole, of which each part, each molecule, each atom, tends to produce another; it is, if we may so speak, one entire ovary, a compound of germ, or feed. In cutting a polype to pieces, the nourishing juices, which would have been employed in supporting the whole, are made to act upon each portion.

When a polype is divided longitudinally, it forms two half tubes; the opposite edges of these approach, and in a very short time form a perfect tube. The sides are made to touch each other by certain motions and contractions of the piece; but as soon as the edges come in contact, a slight adhesion takes place, the corresponding vessels unite, and new ones are unfolded, as in a vegetable graft; by this means, the points of connection and cohesion are multiplied, the motion of the fluids are re-established, and with them the vital œconomy. This is performed with more rapidity than in vegetables, because the polype is nearly gelatinous, and it's parts are extremely ductile; this ductility is supported and preserved by the element which it inhabits. The same reasoning

reasoning applies equally to explain the formation of so many heads to a polype, as constitute it a real hydra.

A new polype is formed out of small portions, or fragments, in a very different manner, the operations in nature being always varied, according as the circumstances differ; each fragment is puffed up, the skin separated, and an empty space is formed within it; this part is to become the stomach of the rising polype, which soon sends forth arms, and is formed to the perfection proper to it's kind. We learn from this instance, that the skin of the polype is not so simple as was at first imagined; for we find it dividing itself into two membranes, and forming thereby a cavity fit to perform all the functions of a stomach; but why these membranes are separated in the small portions, and not in the larger, we cannot tell; but though we are ignorant of this, and many more circumstances relative to the re-production of these little animals, yet the foregoing facts enable us to understand better the nature of the existence of those polypes which have been turned inside out.

For as that part which formed the interior skin of the stomach, in the little fragments before-mentioned, became the exterior part of the animal, the inside of the polype is consequently so similar to the exterior skin, that one may be substituted for the other, without injuring the vital functions; from hence we might, in some measure, have inferred the possibility of the polypes living after it has been turned inside out, independent of the fact itself.

The viscera of the animal are situated in the thickness of the skin, and absorbing pores are placed both on the inside and out-

side, so that the animal can live whether the skin is turned one way or the other. The Author of nature did not create the polype to be turned as we turn a glove; but he formed an animal whose viscera were lodged in the thickness of the skin, and with powers to resist the various accidents to which it was unavoidably exposed by the nature of its life; and the organization necessary for this purpose was so constructed, that the skin might be turned without destroying life.

Every portion of a divided polype has, like the vegetable bud, all the viscera necessary to its existence; it can, therefore, live by itself, and push forth a head and tail, when placed end to end against another piece. The vegetation consists in uniting the portions, the vessels of each part increase in length, and a communication is soon formed between them, which unites the whole. The ease with which the parts unite, is, as has been observed before, probably owing to their gelatinous nature; for we find many similar instances in tender substances. The solid parts of the embryo, as the fingers, unite in the womb; tender fruit and leaves may be also thus united.

A portion of these creatures is capable of devouring its prey almost as soon as it is divided from the rest. In the structure of those animals which are most familiar to us, a particular place is appropriated for the development and passage of the embryo. But on the body of an animal, which, like a tree, is covered with prolific gems, it is not surprizing that the young ones should proceed from its sides, like branches from a tree. The mother and her young ones form but one whole; she nourishes them, and they contribute to her existence, as a tree supports and is reciprocally supported by its branches and leaves.

OF THE HYDRA PALLENS.

The hydra pallens has been described only by M. Roefel, Infec. 3, Polyp. 465, Plate 76, 77; it is very seldom to be met with, is of a pale yellow colour, and grows smaller gradually from the bottom, the tail is somewhat round or knobbed, the arms are about the length of the body, of a white colour, and generally seven in number, apparently composed of a chain of globules; it brings forth the young from all parts of its body. Linnæus defines it as *hydra pallens tentaculis subsexis mediocribus*. Pallas as *hydra attenuata corpore flavescente, sursum attenuato*.

OF THE HYDRA HYDATULA.

The next in order is the hydra hydatula, which we have already defined from Linnæus as a hydra with four obsolete arms, and a vesicular body: it is spoken of by many medical writers, who are enumerated in the *Système Naturæ*, p. 1321. It is described also by Hartman, *misc. nat. cur. dec. I. an. 7, obs. 206, dec. II. an. 4, obs. 73*, as *hydatis animata*; also in the *dissert. de inf. viv. p. 50, n. 6, tænia hydatoidea*. Pallas defines it as *tænia hydatigena rugis imbricata corpore pestice bulla lymphaticæ terminato*. The description I shall give the reader will be extracted from the *Philosophical Transactions*, No. 193, by Dr. Tyson, who names it *lumbricus hydropicus*.

In the dissection of a gazella, or antelope, Dr. Tyson observed several hydatides, or films, filled with water, about the bigness of a pigeon's egg, and of an oval form, fastened to the omentum, and some in the pelvis, between the bladder of urine and the rectum;

and he then suspected them to be a particular sort of insect, bred in animal bodies, or at least the embryos or eggs of them.

1. Because he observed them included in a membrane, like a matrix, so loosely, that by opening it with the finger, or a knife, the internal bladder, containing the serum or lymph, seemed nowhere to have any connection with it, but would very readily drop out, still retaining it's liquor, without spilling any of it.
2. He observed that this internal bladder had a neck, or white body, more opaque than the rest of the bladder, and protuberant from it, with an orifice at it's extremity, by which, as with a mouth, it exhausted the serum from the external membrane, and so supplied it's bladder, or stomach.
3. Upon bringing this neck near the candle, the neck moved and shortened itself. Fig. 1, Plate XXI. represents one of these watery bladders inclosed in it's external membrane, it's shape was nearly round, being only a little depressed, or flatted, as a drop of quicksilver will be by lying on a plane. In Fig. 2 the neck is better seen; the external membrane being taken off, an open orifice is found at it's extremity; it consists of circular rings, or incisures, which are more visible when magnified, as in Fig. 3; it then appears granulated with a number of little eminencies all over the surface; the orifice at the extremity seems to be formed by retracting itself inwards; and upon trial it was found to be so; for in Fig. 4, the neck of this polype is represented magnified and drawn out it's whole length; on opening it there were found within the two strings a, which probably convey into the stomach the moisture and nourishment, which the animal, by protruding it's neck, extracts from the external membrane.*

HYDRA

* *Hydra hydratula* habitat in abdomine mammalium, ovium, suum, murium, &c. inter peritoneum et intestina. Vesica lymphatica, pellucida, magnitudine pruni, petiolata.

HYDRA STENTOREA. FIG. 27 AND 28, PLATE XXII.

Tentaculis ciliaribus corpore infundibuliformi.

The arms of this hydra are rows of short hairs, the body trumpet-shaped.

This species of hydra is very common, and has been described by almost every writer on these subjects; it is placed by Muller among the vorticellæ.

Vorticella stentorea caudata, elongata, tubæformis limbo ciliato. Muller animalcula infusoria.

They are named by Mr. Baker and Mr. Trembley the funnel-like polype.

There are three species of them, which are of different colours, green, blue, and white. The white ones are the most common. It is necessary to observe them often, and in various attitudes, in order to obtain a tolerable idea of their structure. They do not form clusters, but adhere singly by their tail to whatever comes in their way; their anterior end is wider than the posterior, and being round gives the animal somewhat of a funnel form, though it is not completely circular, having a sort of slit, or gap, that interrupts the circle. The edge of this opening is furnished with a great number of little fimbriæ, which by their brisk and continual

petiolata corpore cylindrico, in cujus apice os, quod corpore compresso, movet tentacula vix manifesta. Lin. Syst. Nat. p. 1321.

tinual motions, excite a current of water; the small bodies that float or swim near this current, are forced by it into the mouth of the little animal. Mr. Trembley says, that he has often seen a number of very small animalcula fall one after another into the mouth, some of which were afterwards let out again at another opening, which he was not able to describe.

They can fashion their mouths into several different forms. If any thing touches them they shrink back and contract themselves. They live independent of each other, swimming freely through the water in search of their prey, and fix to any thing they meet with.

These animals multiply by dividing themselves, not longitudinally, nor transversely, but sloping and diagonal wise; the proceedings in nature continually varying in every new form of life. Of the two polypes produced by the division of one, the first has the old head and a new tail, the other the old tail with a new head.

To make the description more clear, Mr. Trembley called that with the old head the superior polype, that with the new head the inferior one. The first particular that is observable in these polypes, when they are going to divide, is the lips of the inferior one; a transverse and oblique stripe indicates the part where it is going to divide; the new lips are formed at about two-thirds of the length of the polype, reckoning from the head; the division is made in a sloping line, that goes about half way round the parent animal; these lips are at first discerned by a slow motion, which engages the attention of the observer. They then insensibly approach

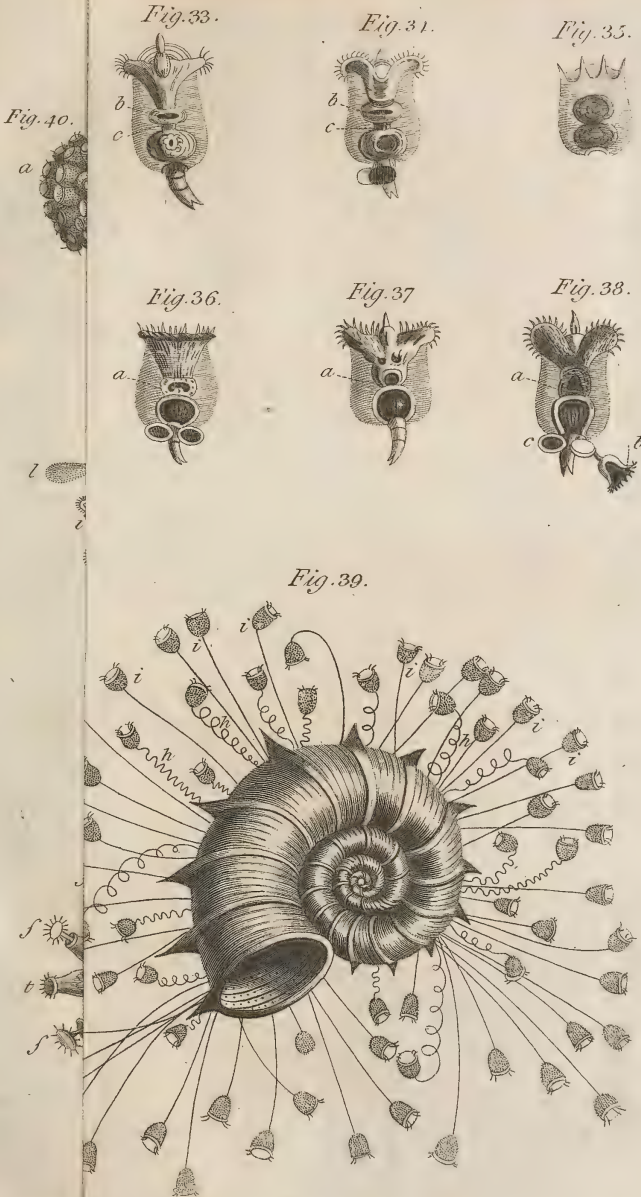


Fig. 25.



Fig. 40.

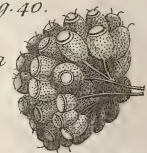


Fig. 26.



Fig. 31.



Fig. 33.



Fig. 34.



Fig. 35.

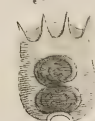


Fig. 36.



Fig. 37.



Fig. 38.



Fig. 27.

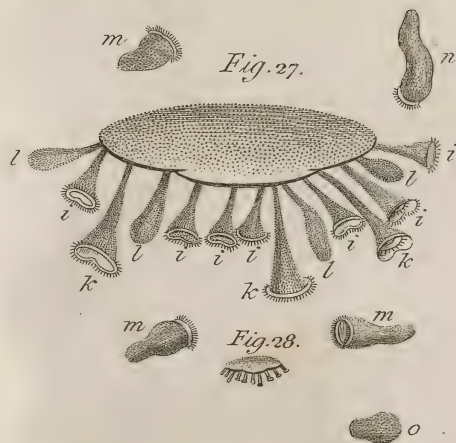


Fig. 30.



Fig. 39.



Fig. 32.

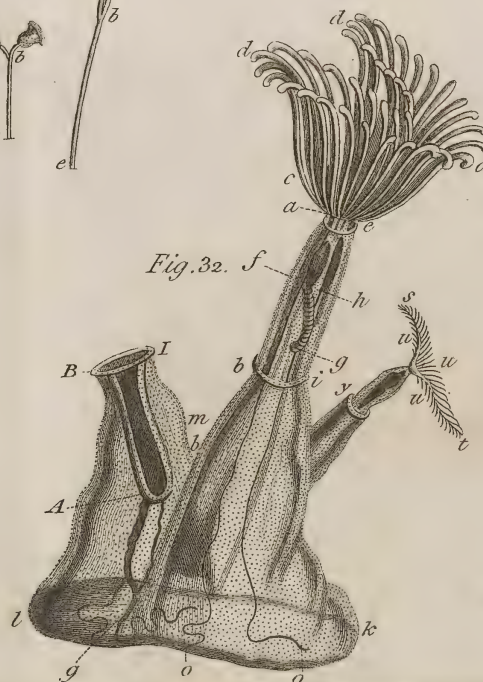


Fig. 29.





approach each other and close, whereby a swelling is formed on the side of the polype, which is soon found to be a new head. When the swelling is considerably increased, the two polypes may be plainly distinguished. The superior one being now connected with the inferior one only by its lower extremity, is soon detached from it, and swims away to fix itself on some convenient substance; the inferior one remains fastened to the place where the original polype was fixed before the division.

From the various modes by which different species of polypes are multiplied, we are led to form more exalted ideas of nature; and to see that the little we discover is but an exceeding small part of her contents; we learn also to be more cautious in reasoning from analogy, and laying down the known for a model to the unknown, because we find that the operations in nature are varied *ad infinitum*.

The growth of the *hydra fusca* is very quick, but that of the *hydra stentorea* is much more so. The progress of the fœtus is always more rapid than that of the infant and adult animal; but in these organized atoms, the evolution is so rapid, as to appear almost like an immediate creation.

Fig. 28 represents the *hydræ stentoræ*, or funnel-polype, fixed to the under side of a piece of some vegetable substance; they are in this figure of their natural size.

Fig. 27, the same polype magnified; the different forms they assume are also seen here, sometimes short and thick as at *m m*, long as at *n*, nearly globular as at *o*, extended to the full size as
at

at k, seen as contracted at i. The fimbriæ, or little hairs, may be seen in most of the attitudes, except those of l.

OF THE HYDRA SOCIALIS.

HYDRA SOCIALIS MUTICA TOROSA RUGOSA. Fig. 11, Pl. XXI.

Bearded thick and wrinkled.

This species of hydra has been described by many writers. It is the vorticella socialis of Muller, who defines it as vorticella caudata, aggregata, clavata; disco obliquo Muller Animalcula infusoria, p. 304. Pallas makes it a brachionus, Pall. Zooph. 53.

In Fig. 11 these animals are represented as considerably magnified; they appear like a circle, surrounded with crowns, or ciliated heads, tied by small thin tails to a common center, from whence they advance towards the circumference, where they turn like a wheel, with a great deal of vivacity and swiftness, till they occasion a kind of whirlpool, which brings into it's sphere the proper food for the polype. When one of them has been in motion for a time, it stops, and another begins; sometimes two or three may be perceived in motion together. They are often to be found separate, with the tail sticking in the mud. The body contracts and dilates very much, so as sometimes to have the appearance of a cudgel, at others to assume almost a globular form. The young polypes of this species have been sometimes taken for the hydra stentorea.

OF THE VORTICELLÆ.

We now come to another division of these animals, to which later writers have given the name of vorticellæ, which we shall therefore adopt, as we think it behoves every man to maintain that order in scientific arrangement which is not inconsistent with truth, except he can produce another arrangement more expressive of the nature of the objects it is designed to discriminate.

The variety that may be observed in these minute animals, confirms a principle, which the more it is looked into, the more it will be found to accord with the general operations in nature, namely, that there is always a pre-existent principle of life necessary to the organization both of animals and vegetables; that the alimentary and other particles which are added to, or apparently belong to them, produce nothing of themselves, they are incapable of forming the least fibre, but they are able to become constituent parts of one organical whole, and the instruments whereby the forming principle is manifested, and rendered capable of acting upon certain orders of creatures.

VORTICELLA.

Animal, calyce vasculoso; ore contractili ciliato, terminali stirps fixa.

A small animal, with a vascular cup; the mouth is at one end ciliated, and capable of being contracted, the stem fixed.

VORTICELLA ANASTATICA.

Vorticella anastatica, composita, floribus campanulatis stirpe multiflora rigescente, see Fig. 13, 14, 15, 16, Plate XXI.

Vorticella anastatica, compound, with bell-shaped flowers, and a rigid stem.

Clustering polype, second species, Trembley, *Philos. Trans.* vol. xlv. part 2, p. 643.

These polypes form a group resembling a cluster, or more properly an open flower; this flower, or cluster, is supported by a stem, which is fixed by it's lower extremity to some of the aquatic plants, or extraneous bodies, that are found in the water; the upper extremity forms itself into eight or nine lateral branches, perfectly similar to each other; these have also subordinate branches, whose collective form much resembles that of a leaf. Every one of these assemblages is composed of one principal branch, or nerve, which makes with the main stem of the cluster an angle somewhat greater than a right one; from both sides of this nerve the smaller lateral branches proceed; these are shorter the nearer their origin is to the principal branch.

At the extremity of the principal branch, and also of all the lateral ones there is a polype or vorticella. There are others on both sides of the lateral twigs, but at different distances from their extremity. These polypes are all exceeding small, and of a bell-like figure; near their mouth a quick motion may be discerned, though not with a sufficient distinctness to convey an adequate idea
of

of it's cause; upon the branches of these clusters are round bodies, which will be more particularly described presently.

Every cluster has eight or nine of these branches, or leaves; they do not all proceed from the same point, but the points from whence they set out are not far asunder; each of these branches is bent a little inwards, so that all of them taken together form a kind of shallow cup. If the eye is placed right over the base of this cup, the appearance of the whole eight or nine branches is like unto that of a star, with so many rays proceeding from the center. If the cluster is slightly touched, all the branches instantly fold up, and form a small round mass. The stem which supports the cluster contracts also at the same time, folding up like a workman's measuring rule, that consists of three or four joints. This extraordinary assemblage constitutes one organized whole, formed of a multitude of similar and particular ones. A new species of society, in which all the individuals are members of each other in the strictest sense, and all participate of the same life.

A few days after one of these clusters is formed, small round bodies, or bulbs, may be perceived to protrude in several places from the body of the branch; these grow very fast, and arrive at their greatest growth in two or three days. The bulbs detach themselves from the branches out of which they spring, and go away, swimming till they can settle upon some substance which they meet with in the water, and to which they fix themselves by a short pedicle; the bulbs are then round, only a little flattened on the under side, the pedicle continues to lengthen gradually for about twenty-four hours, during the same time the bulbs also change their figure, and become nearly oval. There are in a

cluster but few of these bulbs compared with the number of the vorticellæ, neither do all the bulbs come out at the same time. The bulb then divides lengthways into two smaller ones, but which are still much larger than the vorticellæ themselves. It is not long before these are separated like the first, and thus form four bulbs on the same stalk; these again divide themselves, and form eight, which again subdivide, and consequently make sixteen. They are all connected with the stalk by a proper pedicle, but they are not all of an equal size; the largest continue to divide, and the smallest begin to open, and take the bell-formed shape. Mr. Trembley observed from one round bulb, in about twenty-four hours, by repeated divisions, one hundred and ten vorticellæ to be formed.

It has been asked with propriety, what plant, or what animal, could have led us to expect an existence and mode of propagation similar to that of the vorticella anastatica?

Fig. 13 represents one branch of the vorticella anastatica; on this branch, besides the vorticellæ which are of a bell-like form, some of those round bodies from which they first spring, and by which they are so remarkably distinguished from many other species, may be seen.

Fig. 14 represents one of the globular bodies, after it has parted from the cluster, and has fixed itself to some other body, and after the globule itself and its pedicle have begun to lengthen.

Fig. 15 represents the two bodies that were formed by the parting of that which is represented in Fig. 14.

Fig:

Fig. 16 represents four that were formed by the separation of the two bulbs, represented in the foregoing figure.

VORTICELLA PYRARIA.

Composita, floribus muticis obovatis, tentaculis bigeminis stirpe ramosa, Fig. 25 and 26, Plate XXII. Compound, with beardless oval florets, two double arms, the stem branched. Lin.

It is somewhat of a pear shape, the base is pellucid, the top truncated; the lateral arms, which are a pair on each side, cannot be distinguished without some attention; they are sometimes to be seen disengaged from the pedicle, and rolling swiftly in a kind of circle.

VORTICELLA CRATÆGARIA.

Vorticella composita, floribus muticis globosis, tentaculis binis, stirpe ramosa, Fig. 40, Plate XXII. Compound, with globous naked florets, two tentacles, and a branched stem.

These vorticellæ are to be found in the month of April, both in the mud, and upon the tail of the *monoculus quadricornis*; they are generally heaped together in the manner in which they are represented in the figure; they are of a spherical form, and united to one common stalk. They are also often to be found without any pedicle, the body is rather contracted, the aperture is circular, and surrounded with a marked margin; it has two small arms; with a deep magnifier, a vehement rotatory motion may be seen; they sometimes separate from the community, and

go forwards in a kind of spiral line, and then in a little time come back again to the rest.

Fig. 40 represents a parcel of these vorticellæ united together.

Among the other authorities for this animal, M. Linnæus refers to Mr. Baker's description of the mulberry insect, "Employment for the Microscope," p. 348, which, as it differs a little from the preceding account, we shall insert here. That from which his drawing was made, and which he has described, was found in a ditch near Norwich; he called it the mulberry insect, from the resemblance it bore to that fruit; though the protuberances that stand out round it are more globular than those of a mulberry; it is to be seen rolling about from one place to another, and is probably a congeries of animalcula; they are to be met with in different numbers of knobs, or protuberances, some having fifty or sixty, others more or less down to four or five. The manner of moving is the same in all. They are generally of a pale yellow.

VORTICELLA OPERCULARIA, FIG. 29, PLATE XXII.

Vorticella composita, floribus muticis ovalibus, stirpe ramosa.
Compound, with naked oval florets, and a branched stem.

These vorticellæ are of a lemon shape, and are generally found in clusters, branching out from a stem, which mostly adheres to some convenient substance.

That species of them which is described by Mr. Baker had a very short pedicle, and the animals were much longer than those
which

which are represented at Fig. 29, Plate XXII. There was no main stem, but all the pedicles were joined in one center, round which the animals extended themselves as so many radii, forming a very pleasing figure.

The mouths of these animalcula are not ciliated, but they are furnished with a round operculum, or cover, connected by a long ligament, or muscle, which extends downwards through the body, and is affixed within side of it, near the tail. This ligament may be contracted or dilated, so that the cover may be removed to some distance from the mouth; in this situation several short hairs may be found to radiate from it; these have a vibratory motion, by which they excite a current of water, most probably to draw in the proper nourishment, after which they shut or pull down the cover, which they again extend at pleasure; when the cover is pulled close down, the mouth contracts, and no hairs are to be seen.

Fig. 29 represents the vorticella opercularia, f the operculum removed at some distance from the mouth, at t, it is nearly close at r, the mouth contracted, the cover drawn in, and no hairs to be seen; u a part of the stalk, from which some of the animalcula are separated.

VORTICELLA UMBELLARIA.

Vorticella composita, floribus ciliatis globosis muticis, stirpe umbellata, Fig. 30, Plate XXII. Compound, with ciliated globous naked florets, and an umbellated stem.

Vorti-

Vorticella acinosa, simplex, globosa, granis nigricantibus, pedunculo rigido. Muller *Animal Infus.* p. 819; sub fig. 20. and 21.

We often find in divers places, upon water, plants, and other bodies in the water, a whitish substance, that looks like mould; plants, pieces of wood, snail shells, &c. are often entirely covered over with this substance. If we examine any of these by the microscope, we shall find such motions as will induce us to think them an assemblage of living animals, minute bodies, severally fixed to the extremities of small stems, or pedicles, many of which are often so united as to form together a sort of branches, or clusters, from whence they have been termed clustering polypes, or *des polypes en bouquet*.

These clusters are larger or smaller, according to the species of the vorticellæ which form them, and according to the concurrence of many other circumstances. To get a clear idea of the figure of these animals, it is best to observe the smaller clusters, as in the larger they are often rendered less distinct on account of the number.

The length of those which are represented at Fig. 30, is about the 240th of an inch; they are of a bell-shape. The anterior part a c generally appears open, the posterior part is fixed to a stem, or pedicle, b e; it is by the extremity of this pedicle that the vorticella fastens itself to any substance. It appears in the microscope of a brownish colour, excepting at the smaller end b, where it is transparent, as well as the whole pedicle b e. When the anterior part a c is open, a very lively motion may be perceived about it's edges; and when it presents itself in a particular manner, some-

thing very much resembling the little wheels of a mill, moving with great velocity, may be discovered on both sides of the edges of this anterior part.

These vorticellæ are able to contract themselves suddenly. They may be made to do this, either by touching them, or moving the substance to which they are affixed. When they contract, the edges of the anterior parts are drawn quite into the body; on resuming their former posture, the edges may be seen to come forth, and put themselves in motion as before. Minute substances that float in the water are often forced down into these openings, and sometimes are thrown out again.

They are capable of swimming about singly, but their form is in that case considerably different from that which they have when they are fixed. To see regularly in what manner the clusters are formed, and in what way these little creatures multiply, it is best to observe one that is fixed by itself.

The pedicle of a single vorticella is at first short, but it soon grows longer, and then begins to multiply, that is, to divide, or split itself in two lengthways. To effect this, the lips are first drawn into the body, the anterior part closes and becomes round, and loses its bell shape, the motion about the lips ceases, though a small degree of motion may be perceived within the body. The anterior end flattens gradually, and spreads wider in proportion as it grows smaller. It then gradually splits down the middle, that is, from the middle of the head to the pedicle, so that in a little time two separate round bodies appear to be joined to the end of the pedicle, that before supported but one.

The mouth, or anterior part of each of these bodies, now opens by degrees; and in proportion as they open, the lips of the new vorticellæ begin to display themselves. The motion before spoken of may then also be perceived. Indeed it is the best time of observing it; it is at first slow, but more rapid in proportion as the mouth opens, when it is as swift as that of the vorticellæ before it began to divide, and we may now look upon it as completely formed. A vorticellæ is generally about one hour in dividing itself.

The lower of the three drawings, Fig. 30, represents two vorticellæ joined by their posterior extremity to one pedicle; soon after the division, each vorticellæ begins to shew a pedicle of its own.

Fig. 30 represents a cluster of eight vorticellæ; by this figure we may form some idea in what manner the pedicles are disposed as their number increases; there were at first only two at b, whose branches lengthened to d, and then each of them was divided into two, now forming four; these again lengthened and reached i, when they were again subdivided, as in the figure.

The reader will join with M. Bonnet in admiring the group of wonders afforded by a single spot of mouldiness. What unforeseen, varied, and interesting scenes are presented within so small a compass! what a theatre is exhibited to a thinking mind! But our abode is so reclusive, that we have but a glimmering view of it: how great would our astonishment be, if the whole spectacle was disclosed to us at once, and we were enabled to penetrate into the interior structure of this wonderful assemblage of living atoms!

Our eyes see only the gross part of the decorations, whilst the machines that execute them remain in impenetrable darkness! Who shall enlighten this profound obscurity, or dive into an abyss where reason is lost, or draw from thence the treasures of wisdom concealed within it? Let us learn to be content with the small portion that is communicated to us, and contemplate with gratitude the first traces of human understanding that are imparted to us in these discoveries.

VORTICELLA BERBERINA.

Vorticella composita, floribus ovalibus muticis, stirpe ramosa. Compound, with oval beardless florets.

This is a species of the vorticellæ, which resemble the preceding one in many respects, particularly in being multiplied in the same manner, that is, by dividing, or splitting, according to its length.

They are more slender than the vorticella umbellaria; the branches of the clusters are transparent. When many of them are together, they appear of a changeable violet colour; the clusters are not unlike a sprig of spun glass. The motion of the lips is not so easily distinguished as in the foregoing species, though it may be observed in these whilst they are opening and completing their formation. For at these times the motion is but slow, whereas it becomes afterwards very quick in those that are arrived at a state of perfection.

All the cluster vorticellæ detach themselves from time to time from the stem, and from these they swim about till they fix again upon some convenient substance; the branches, when deserted, bear no more vorticellæ.

VORTICELLA DIGITALIS.

Vorticella composita, floribus cylindricis, unifulcatis semiclausis, stirpe ramosa, Fig. 31, Pl. XXII. Compound, with cylindrical florets.

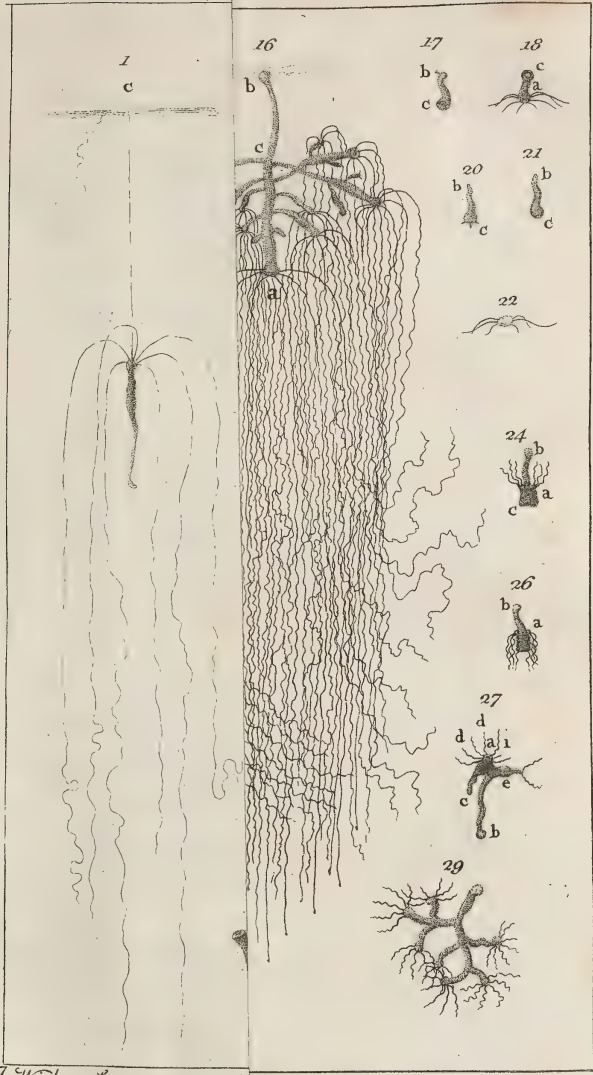
Vorticella composita, cylindrica, crystallina, apice truncata et fissâ, pedunculo fistuloso ramosa. Muller Animal Infus. p. 327.

This species of the vorticella is very scarce, it seems only to have been seen by Roefel, who found it on the monocus quadricornis, till 1784, when it was discovered by Mr. Muller, who had sought for it several years before in vain.

The body is cylindrical, crystalline, and appears almost empty; it has three pellucid points disposed lengthways, the apex is truncated in an oblique direction, the margin bent back. The upper part contracts itself, and the margin then assumes a conical shape, with a convex surface; there are in general but few branches from the principal stem, and these are short and thick; it excites an undulatory motion, but no hairs, nor any rotatory motion, have been discovered. Fig. 31, o and n, represents the vorticella adhering to the monocus quadricornis.

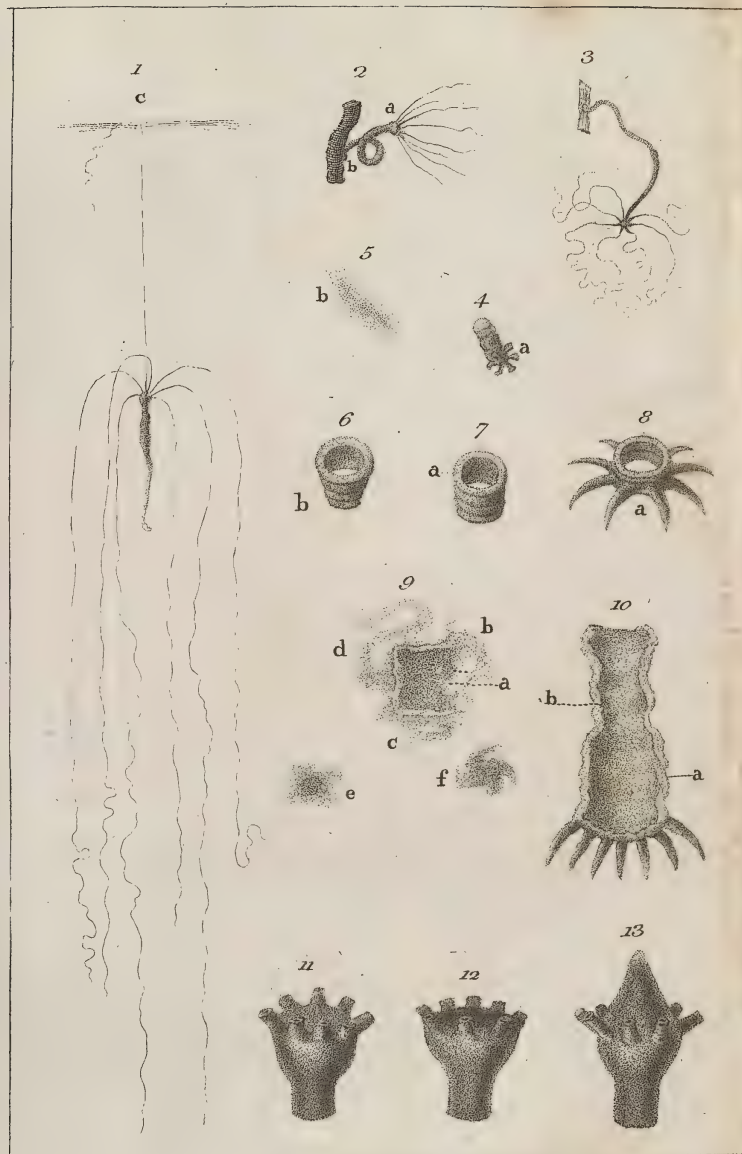
VORTI-

Pl. 23.B.



J. Wiggley. Sc.

Bowles sc.



J. Wiggley. Sc.

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60, Fleet Street, as the act directs, 20 May 1737.

Bowles sc.



VORTICELLA CONVALLARIA.

Simplex, gregaria, flore campanulata mutico, tentaculis bigeminis, stirpe fixa, Fig. 39, Pl. XXII. Simple, but gregarious, the florets bell-shaped, with two pair of little arms, and a fixed stem.

Vorticella simplex, campanulata, pedunculo retortili. Muller Animal Infus.

These vorticellæ, or bell animals, as they are termed by Mr. Baker, are generally found adhering to some substance in the water; they are represented here as found by M. Roesel, fixed to a curious cornu ammonis, with points projecting from the back. To the naked eye they appear only as so many little white points, but under a microscope, as little bells, agitating the water to a considerable distance. The stems of these have a particular motion, they draw themselves up, and shorten all at once, taking the form of a spiral wire, or screw; in a moment after they again resume their former shape, stretching themselves out straight as before. Many of them may be seen at times adhering to each other by their tails; the cilia, which are two on each side of the mouths, are very seldom to be perceived.

VORTICELLA URCEOLARIS. FIG. 33, 34, 35, PLATE XXII.

Simplex, pedunculata, ore dentato. Single, with a short tail, and toothed mouth.

Brachionus capularis testa ovata apice sexdentata basi incisa, cauda longa bicuspi. Muller Animal Infus. p. 356.

To

To the naked eye it appears as a white moveable point; but when examined by the microscope, a tail, projecting from the lower part, is discovered, and a double rotatory instrument is seen, which it can conceal or discover at pleasure. It has been seen and described by most microscopical writers; but as Mr. Baker's seems to us to be the most perfect, we shall principally follow his account of it.

He discovered three species of them, two of which are included under the *vorticella urceolaris*. Fig. 33, 34, 35, are of the first species; Fig. 36, 37, 38, are of the second kind. The first sort, when extended, is about twice as long as it is broad. It is contained in a shell; the fore-part of this is armed with four sharp teeth, or points; the opposite side has no teeth, but is waved, or bent, in two places, like the form of a Turkish bow. At the bottom there is a hole, through which it pushes the tail. It fastens itself by this tail to any convenient substance, when it intends to use its rotatory organs; but when it is floating in the water, and at all other times when not adhering to any body, it wags the tail backwards and forwards something like a dog.

We may consider it as divided into a head, thorax, and abdomen; each of which may be extended and contracted considerably: it can by dilating all three protrude the head beyond the shell, or by contracting them, draw the whole body within the same.

The head when extended divides itself into two branches, between which another part, a kind of proboscis, is pushed out; at the end of this are two fibrils, that appear when they are at rest

rest like a broad point, but which can be moved to and from each other very briskly with a vibratory motion, see Fig. 33.

The form and situation of the two branches is sometimes changed, the ends thereof becoming more round, and the vibratory motion is altered to a rotatory one: this alteration is represented at Fig. 34: the head also appears in this figure. The thorax is annexed to the lower part of the head, it is muscular; within it there is a moving intestine, which has been supposed to be either the lungs or the heart of the little creature, see b, Fig. 33 and 34.

A communication is formed between the thorax and the abdomen by means of a short vessel c, whose alternate contractions and dilatations occasion the abdomen to rise and fall alternately, having at the same time a sort of peristaltic motion. The food is conveyed through this vessel into the abdomen, where it is digested; it is then discharged by the anus, which is placed near the tail.

The tail has three joints, and is cleft or divided at the extremity, by which means it can better fasten itself to suitable objects. It is in general projected from the lower end of the shell, moving nimbly to and fro, serving the animal as a rudder when it is swimming to direct its course.

When the water in which the little animal is placed is nearly dried away, or when it has a mind to compose itself to rest, it contracts the head and fore-part of the body, and brings them down into the shell, and pulls the tail upwards, so that the whole
of

of this minute creature is contained within the shell, see Fig. 35. The shell is so transparent that the terminations cannot be easily distinguished when the animal is extended; but whatever is transacted within the shell, is as plain as if there was no substance between the eye and the interior parts.

Fig. 36, 37, 38, exhibit the appearance of another species of these animals, which differs from the foregoing kind. This has also a head, a thorax and abdomen, but then they are not separated by a gut or intermediate vessel, as in the former, but are joined immediately together, and at the place where in the first kind a moveable intestine was seen; in this a muscle, most probably the heart, may be discovered; it has a regular systole and diastole: this part is intended to be shewn at a, Fig. 36, 37, 38. Like the other it draws the head and tail within the shell, which then appears to have six teeth or spikes on one side, and two on the other: it very seldom protrudes its head so far out as the other; sometimes the fibrillæ may be seen within the margin of the shell.

Both species carry their young in an oval integument or bag, fastened externally to the lower part of the shell, somewhere about the tail; these bags are sometimes opaque at one end, and seemingly empty at the other, see Fig. 34: sometimes the middle is opaque, with a transparent margin, see Fig. 36.

It is highly entertaining to see a young one burst its integument, and gradually force its way out; in performing this operation, it is much assisted by the motion of the tail of the parent. The head part comes out first, it then sets its rotatory organ in motion,

motion by which it is completely disengaged, leaving the integument behind, which the vorticella freed itself from by repeated strokes with it's tail. A young one almost disengaged is seen at b, Fig. 38; another embryo, c, was left adhering to the shell.

There are four more species of the vorticella mentioned by Linnæus, which are the vorticella encrinus, the vorticella polypina, the vorticella stellata, and the vorticella ovifera, which do not come properly within our plan. The vorticella polypina will be described hereafter. There is, however, another little animal, of which we have given a figure in Plate XXII. and which Linnæus, in a former edition of the *Systema Naturæ*, placed among the hydræ, but which he has since removed, and placed amongst the tubularia; and as I do not feel myself competent to controvert the propriety or impropriety of the former or present arrangement, the little creature must here take a solitary situation, and stand without a companion.

TUBULARIA CAMPANULATA. FIG. 32, PLATE XXII.

Reptans, tubis campanulatis. Creeping, with campanulated tubes.

It is called by Mr. Baker the bell-flowered, or plumed animal.

These little creatures dwell in colonies together, from ten to fifteen in number, living in a kind of slimy mucilaginous case, which, when expanded in the water, has some resemblance to a bell with it's mouth upwards. These bells, or colonies, are to

be found adhering to the large leaves of duck-weed and other aquatic plants.

The bell, or case, which these animals inhabit, being very transparent, all the motions of it's inhabitants may be discerned distinctly through it. There are several ramifications, or smaller bells, proceeding from the larger one; in each of these there is an inhabitant. The opening at the top of these bells is just large enough for the creature's head and a small part of it's body to be thrust out from it, the rest remaining in the case, into which it also draws the head on the least alarm.

Besides the particular and separate motions which each of these creatures is able to exert within it's case, and independent of the rest, the whole colony has a power of altering the position of the bell, and removing it from one place to another. These animalcula seem not to like to dwell in societies whose number exceeds fifteen; when the colony happens to increase in number, the bell may be observed to split gradually, beginning from about the middle of the upper extremity, and proceeding downwards towards the bottom, till they at last separate and become two colonies, independent of each other.

The arms are very near each other; sixty may often be counted in one plume, having each the figure of an Italic *f*; one of whose hooked ends is fastened to the head; and all together, when expanded, compose a figure somewhat like a horseshoe, convex on the side next the body, but gradually opening and turning outwards, so as to leave a considerable distance within the outer extremities

tremitics of the arms. When the arms are thus extended, the creature, by giving them a vibratory motion, can produce a current in the water, which brings the animalcula, and other minute bodies that are floating near it, into it's mouth, situated between the arms. The food, if agreeable to the creature, is swallowed; if not, it is rejected by a contrary motion. As the skin is transparent, the animal may be seen very plain when it has retired within the tube.

The body is about one-eighth of an inch long, without reckoning the plume, which is about the same length. It is cylindrical, and the skin is very transparent. The plume is only a continuation of this transparent skin, it is very broad in proportion to the body, and of a remarkable figure; the base is of the shape of a horseshoe, from this base the arms project, they bend rather outwards. The plume which they form gives them a resemblance to some flowers. The arms may be compared, from their fineness and transparency, to very fine threads of glass. The base of the plume is grooved, and is fixed to the animal by the middle of the horseshoe which it forms, and it is here that there is an opening which serves as a mouth to the animal. The intestines are easily distinguished through it's transparent skin; when it has just been eating, they are of a deep brown colour. Three principal parts may be distinguished, the oesophagus e h i, the stomach f g, and the rectum f a.

The plumed polype is very voracious, devouring a great number of small animals. The arms, when observed attentively with the microscope, will be found to bend from moment to moment within side of the plume, and then rise up again;

then another arm performs the same; thus by the continual motion of it's arms, it puts the water into violent agitation, and brings into it's mouth the food whereby it is nourished.

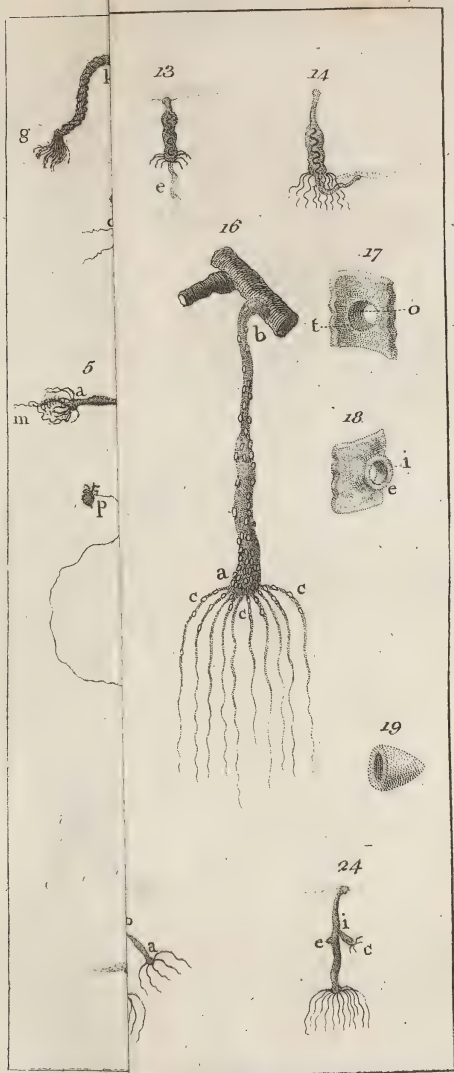
In the inside of these animals a small oblong whitish body is formed, which is carried to the outside, and remains fixed in a perpendicular direction to the body; many of these are formed daily, and of these oval bodies new animals are produced, exactly similar to the parent.

If these minute bodies are eggs, they are of a singular kind, being destitute of any covering, and are neither membranaceous nor crustaceous; we cannot with propriety say the young ones are hatched from them; we can, however, perceive these oviform bodies to gradually unfold themselves. The developement is accomplished in a few minutes, and an animalculum appears like the parent.

Mr. Trembley amassed a large quantity of these eggs, and carried them from England with him, keeping them quite dry; on putting them into water, they gradually developed, and became as perfect as the tubularia from which they proceeded.

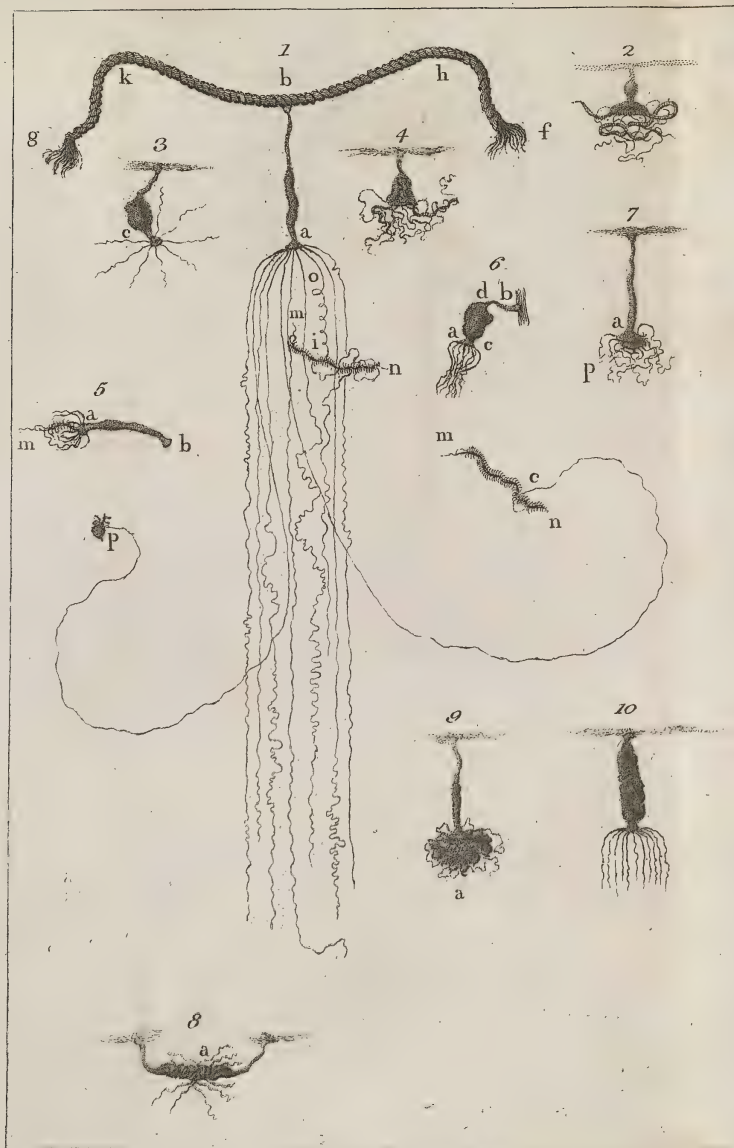
There is a very great similarity in the construction of this little creature, and many of the marine polypes, who, like it, exist in tubes of the same growth with themselves.

Fig. 32 represents three tubulariæ campanulatæ, or plumed polypes, very much magnified, namely, b f a c d d e h g i, which is out of it's cell; I B A C, which is within it's cell, and the young one,



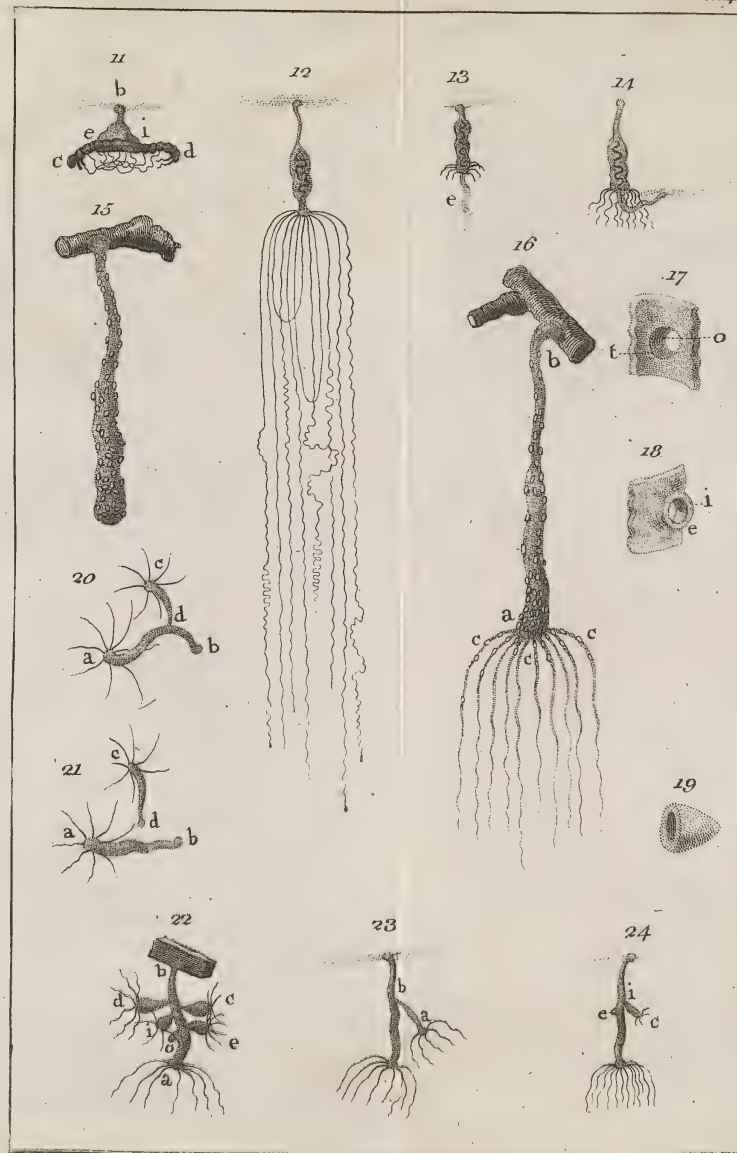
J. Witley. Sc.

Bowles sc.



J. Wigley. Sc.

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60 Fleet Street, as the act directs, 20 May 1787.

Bowles sc.



one, t u s, which is out of it's cell; e h the oesophagus, f g the stomach, a f the rectum, a c d d e the plume, consisting of the base e a c, which is but little seen, and the arms ad ad ad which proceed from the edges of this base; I B A C one of the animals drawn into it's cell, I A B the skin reversed, in which the plume is contained; g o o threads which are fixed at one end to the intestines of the animal, by the other to the bottom of the cell.



C H A P. VIII.

OF THE ANIMALCULA INFUSORIA.

OUR knowledge of the microscopic world is at present very contracted, but we know enough to give us high conceptions of its concealed wonders, and to fill us with profound astonishment at the infinite variety of forms that are made recipient of life. A few of the inhabitants of this world have been discovered. The figure and apparent habits of life of these, resemble so little those with which we are more acquainted, that it is often difficult to find terms to express what is presented to the eye. It is highly probable that there are many gradations of existence far below the minutest of those which we observe with the microscope; and though by this we are enabled to discover myriads of different creatures roving in the least drop of water, as if it were a sea, yet it is not unreasonable to suppose that HE who has filled the immensity of extent with suns and worlds, has peopled every particle of fluids with more minute beings than any apparatus of our's can perceive, agreeable to the sublime ideas of the poet:

Gradual

Gradual from these what num'rous kinds descend,
 Evading even the microscopic eye !
 Full nature swarms with life ; one wond'rous mass
 Of animals, or atoms organized,
 Waiting the vital breath, when parent heaven
 Shall bid his spirit blow. The hoary fen,
 In putrid steams, emits the living cloud
 Of pestilence ; thro' subterranean cells,
 Where searching sun-beams scarce can find a way,
 Earth animated heaves. The flowery leaf
 Wants not it's soft inhabitants. Secure,
 Within it's winding citadel, the stone
 Holds multitudes. But chief the forest boughs,
 That dance unnumber'd to the playful breeze,
 The downy orchard, and the melting pulp
 Of mellow fruit, the nameless nations feed
 Of evanescent insects. Where the pool
 Stands mantled o'er with green, invisible,
 Amid the floating verdure, millions stray.
 Each liquid too, whether it pierces, soothes,
 Inflames, refreshes, or exalts the taste,
 With various forms abounds. Nor is the stream
 Of purest crystal, nor the lucid air,
 Tho' one transparent vacancy it seems,
 Void of their unseen people. These, conceal'd
 By the kind art of forming heaven, escape
 The grosser eye of man :

* * * * * * * *
 * * * * * * * *
 * * * * * * * *

Let

Let ne prefuming impious railer tax
Creative Wifdom; as if aught was form'd
In vain, or not for admirable ends.
Shall little haughty Ignorance pronounce
His works unwife, of which the fmalleft part
Exceeds the narrow vifion of her mind?
As if upon a full proportion'd dome,
On fwelling columns heav'd, the pride of art!
A critic fly, whose feeble ray fcarce freads
An inch around, with blind prefumption bold,
Should dare to tax the ftructure of the whole.
And lives the man, whose univerfal eye
Has fwep't at once th' unbounded fcheme of things;
Mark'd their dependance fo, and firm accord,
As with unfaultering accent to conclude
That this availeth nought? Has any feen
The mighty chain of beings leffening down
From infinite perfection to the brink
Of dreary nothing, defolate abyfs!
From which aftonifh'd thought, recoiling, turns?
Till then alone let zealous praife afcend,
And hymns of holy wonder, to that Power,
Whofe wifdom fhines as lovely on our minds,
As on our fmiling eyes his fervant fun.

THOMPSON.

Animal-

Animalculum signifies a little animal, and therefore the term might be applied to every animal which is considerably inferior in size to ourselves. It has been customary, however, to distinguish by this name only those animals that are of a size so diminutive, that their true figure cannot be discerned without the assistance of glasses, and is more especially applied to such as are altogether invisible to the naked eye, and cannot be perceived even to exist but by the aid of microscopes.

By these we are brought into a new world, and numberless animals are discovered, which, from their minuteness, must otherwise for ever have escaped our observation: and how many kinds of these invisibles there may be, is yet unknown; as they are discerned of all sizes, from those which are barely invisible to the naked eye, to such as resist the action of the microscope, as the fixed stars do that of the telescope, and with the greatest powers hitherto invented, appear only as so many moving points.

The smallest living creatures our instruments can shew, are those that inhabit the waters; for though animalcula, equally minute, may fly in the air, or creep upon the earth, it is scarce possible to get a view of them; whereas, water being transparent, and confining the creatures within it, we are enabled, by applying a drop of it to our glasses, to discover with ease a great part of it's contents.

It has been long known, that if seeds, herbs, or other vegetable substances, are infused in water, the water will soon be filled with an indefinite number of little animals. We find them, in general, moving in all directions with equal ease and rapidity,

sometimes obliquely, sometimes strait forwards, at other times circularly, one while rolling and turning round, and then running backwards and forwards through the whole dimensions of the drop, as if in sport; at other times attacking with avidity the little heaps of matter they meet with in their way. They know how to avoid with dexterity any obstacles that would interrupt their motion, and even to avoid one another; you may see hundreds in motion in a drop of water, that never strike against each other; sometimes they will suddenly change the direction in which they are moving, and take one diametrically opposite thereto. By inclining the glass on which the drop of water is laid, it may be made to move in any direction; the animalcula in the drop will swim as easily against the stream as with it.

If the water begins to evaporate, and the drop to grow smaller, they flock impetuously towards the remaining fluid; an anxious desire of attaining this momentary respite of life is very visible, as well as an uncommon agitation of the organs by which they imbibe the water. These motions grow languid as the water fails, till they at last cease. If they are left dry for a little time, it is impossible to re-animate them by giving them fresh water.

Animalcula and insects will support a great degree of cold, but both one and the other perish when it is carried beyond a certain point. The same degree of heat that destroys the existence of insects, is fatal to animalcula; as there are animalcula produced in water at the freezing point, so there are insects which live in snow.

If the smallest drop of urine is put into a drop of water, where these animalcula are roving about, apparently happy and easy, they instantly fly to the other side, but the acid soon communicating itself to this part, their struggles to escape are increased, but the evil also increasing, they are thrown into convulsions, and soon expire.

Among animalcula, as in every other part of nature, there is always a certain proportion preserved between the size of the individuals and their number. There are always fewest amongst the larger kinds, but they increase in number as they diminish in size, till of the last or lowest to which our powers of magnifying will reach, there are myriads to one of the larger. Like other animals, they increase in size from their birth till they have attained their full growth. When deprived of food, they grow thin and perish, and different degrees of organization are to be discovered in their structure.

The birth and propagation of these microscopic beings is as regular as that of the largest animals of our globe; for though their extreme minuteness prevents us, in most cases, from seeing the germ from which they spring, yet we are well assured, from numerous observations, that the manner in which they multiply is regulated by constant and invariable laws.

We have seen that different species of the hydra and vorticella multiply and increase by natural divisions and subdivisions of the parent's body; this manner of propagation is very common among the animalcula in infusions, though with many remarkable varieties. Some multiply by a transverse division, a contraction

takes place in the middle, forming a kind of neck, that becomes smaller every instant, till they are enabled by a slight degree of motion to separate from each other. These animalcula, in general, studiously avoid each other; but when they are in the labour of multiplication, and the division is in great forwardness, it is not uncommon to see one of them precipitate itself on the neck of the dividing animalcula, and thus accelerate the separation.

Another species, when it is on the point of multiplying, fixes itself to the bottom of the infusion; it then forms an oblong figure, afterwards becomes round, and begins to turn rapidly, as if upon an internal center, continually changing the direction of it's rotatory motion; after some time, we may perceive two lines on the spherule, forming a kind of cross; soon after which, the animalculum divides into four, which grow, and are again subdivided.

Some multiply by a longitudinal division, which in one kind begins in the fore-part, and others in the hind-part; from another kind a small fragment is seen to detach itself, which very soon acquires the form of the parent animalculum. Lastly, some propagate in the same manner as those we deem more perfect animals.

From what has been said, it appears clearly that their motions are not purely mechanical, but are produced by an internal spontaneous principle, and that they must therefore be placed among the class of living animals, for they possess the strongest marks, and the most decided characters of animation; and consequently, that there is no foundation for the supposition of a chaotic and neutral kingdom, which can only have derived it's origin from a very transient and superficial view of these animalcula.

It

It may also be further observed, that as we see that the motions of the limbs, &c. of the larger animals are produced by the mechanical construction of the body, and the action of the soul thereon, and are forced by the ocular demonstration which arises from anatomical dissection, to acknowledge this mechanism which is adapted to produce the various motions necessary to the animal; and as when we have recourse to the microscope, we find those pieces which had appeared to the naked eye as the primary mechanical causes of the particular motions, to consist themselves of lesser parts, which are the causes of motion, extension, &c. in the larger; when the structure can therefore be traced no further by the eye or glasses, we have no right to conclude, that the parts which are invisible are not equally the subject of mechanism: for this would be only to assert in other words, that a thing may exist because we see and feel it, and have no existence when it is not the object of our senses.

The same train of reasoning may be applied to microscopic insects and animalcula; we see them move, but because the muscles and members which occasion these motions are invisible, shall we infer that they have not muscles, with organs appropriated to the motion of the whole and its parts? To say that they exist not, because we cannot perceive them, would not be a rational conclusion. Our senses are indeed given us, that we may comprehend some effects; but then we have also a mind with reason bestowed upon us, that from the things which we do perceive with our senses, we may deduce the nature of those causes and effects which are imperceptible to the corporeal eye.

Meffrs.

Messrs. Buffon, Needham, and Baron Munckhausen, have considered this part of animated nature in so different a light from other writers, that we cannot with propriety entirely pass them over. Mr. Needham imagined that there was a vegetative force in every microscopical point of water, and every visible filament of which the whole vegetable contexture consists; that the several species of microscopic animals may subside, resolve again into gelatinous filaments, and again give lesser animals, and so on, till they can be no further pursued by glasses. That agreeable to this idea, every animal, or vegetable substance, advances as fast as it can in it's revolution, to return by a slow descent to one common principle, whence it's atoms may return again, and ascend to a new life. That notwithstanding this, the specific seed of one animal can never give another of a different species, on account of the preparation it must receive to constitute it this specific seed.

M. Buffon asserts, that what have been called spermatic animals, are not creatures really possessing life, but something proper to compose a living creature, distinguishing them by the name of organic particles, and that the moving bodies which are to be found in the infusions, either of animal or vegetable substances, are of the same nature.

Baron Munckhausen supposed that the seeds of mushrooms were first animals, and then vegetables; and this because he had observed some of the globules in the infusions of mushrooms, after moving some time, to begin to vegetate.

It

It might be sufficient in the first instance to observe, that Mess. Needham and Buffon, by having recourse to a vegetative force, and organic particles, to account for the existence, and explain the nature of animalcula, and the difficulties of generation, have substituted words in the place of things, and that we are no gainers by the substitution, unless they explain the nature of these powers. But to this we may add, that all those who have examined the subject with accuracy and attention, as Bonnet, De Saussure, Baker, Wrisberg, Spalanzane, Haller, Ellis, Muller, Leder Muller, Corti, Roffredi, &c. disagree with the foregoing gentlemen, proving that they had deceived themselves by inaccurate experiments, and that one of them, M. Buffon, had not seen the spermatric animals he supposed himself to be describing, inasmuch that Mr. Needham was at last induced to give up his favorite hypothesis.

To this we may add, that though we can by no means pretend to account for the appearance of most animalcula, yet we cannot help observing, that our ignorance of the cause of any phenomenon is no argument against its existence. Though we are not, for instance, able to account in a satisfactory manner for the origin of the native Americans, yet we suppose M. Buffon himself would reckon it absurd to maintain, that the Spaniards on their arrival there found only ORGANIC PARTICLES moving about in disorder. The case is the very same with the eels in paste, to whose animation he objects. They are exceedingly small in comparison with us; but, with the solar microscope, Mr. Baker has made them assume a more respectable appearance; so as to have a diameter of an inch and an half, and a proportionable length. They swam up and down very briskly;

briskly; the motion of their intestines was very visible; when the water dried up, they died with apparent agonies, and their mouths opened very wide. Now, were we to find a creature of the size of this magnified eel gasping in a place where water had lately been, we certainly should never conclude it to be merely an ORGANIC PARTICLE, or fortuitous assemblage of them, but a fish. Why then should we conclude otherwise with regard to the eel in its natural state, than that it is a little fish? In reasoning on this subject, we ought ever to remember, that however essential the distinction of bodies into great and small may appear to us, they are not so to the Deity, with whom, as Mr. Baker well expresses himself, "an atom is a world, and a world but as an atom."—Were the Deity to exert his power a little and give a natural philosopher a view of a quantity of paste filled with eels, from each of whose bodies the light was reflected as in the solar microscope; our philosopher, instead of imagining them to be mere organic particles, (as the paste would appear like a little mountain,) he would probably look upon the whole as an assemblage of serpents, and be afraid to come near them. Whenever, therefore, we discover beings to appearance endowed with a principle of self-preservation, or whatever we make the characteristic of animals, neither the smallness of their size, nor the impossibility of our knowing how they came there, ought to cause us to doubt of their being animated.*

I shall here insert some extracts of the experiments made by Mr. Ellis at the desire of M. Linnæus, and which are a full refutation of those made by M. Needham and B. Munckhausen. By
those

* Encyclopædia Britannica, vol. I, p. 456.

those he made on the infusions of mushrooms in water, it appeared evidently that the seeds were put in motion by minute animals, which arose on the decomposition of the mushroom; these, by pecking at the seeds, which are little round reddish bodies, moved them about with great agility in a variety of directions, while the little animals themselves were scarce visible till the food they had eaten discovered them.

The ramified filaments, and jointed or coralloid bodies, which the microscope discovers to us on the surface of most vegetable and animal infusions, when they become putrid, and which were supposed by Mr. Needham to be zoophytes, were found by Mr. Ellis to be of that genus of fungi called mucor, many of which have been figured by Michelius, and described by Linnæus. Their vegetation is so quick, that they may be seen to grow and feed under the eye of the observer; other instances of similar mistakes in Mr. Needham's experiments may be seen in Mr. Ellis's paper, *Philos. Transf.* vol. lix. p. 138.

A species of mucor arises also from the bodies of insects putrefying in water; this species sends forth a mass of transparent filamentous roots, from whence arise hollow seed vessels; on the top there is a holé, from which minute globules often issue in abundance, and with considerable elastic force, which move about in the water. It will, however, be found, with a little attention, that the water is full of very minute animalcula, which attack these seeds, and thus prolong their motion; but after a small space of time they rise to the surface, and remain there without any motion; a fresh quantity rises up, and floating to the edge of the water, remains there inactive; but no appearance

can be observed of detached and separated parts becoming what is called microscopic animalcula. Indeed, it is surprizing that Mr. Needham should ever take the filaments of the moistened grains for any thing else than a vegetable production, a true species of mouldiness.

On the 25th of May, Fahrenheit's thermometer 70° , Mr. Ellis boiled a potatoe in the New River water till it was reduced to a mealy consistence. He put part of it, with an equal proportion of the boiling liquor, into a cylindrical glass vessel, that held something less than half a wine pint, and covered it close immediately with a glass cover. At the same time he sliced an unboiled potatoe, and, as near as he could judge, put the same quantity into a glass vessel of the same kind, with the same proportion of New River water not boiled, and covered it with a glass cover, and placed both vessels close to each other.

On the 26th of May, twenty-four hours afterwards, he examined a small drop of each by the first magnifier of Wilson's microscope, whose focal distance is reckoned at $\frac{4}{5}$ part of an inch; and, to his amazement, they were both full of animalcula of a linear shape, very distinguishable, moving to and fro with great celerity; so that there appeared to be more particles of animal than vegetable life in each drop.

This experiment he repeatedly tried, and always found it to succeed in proportion to the heat of the circumambient air; so that even in winter, if the liquors are kept properly warm, at least in two or three days the experiment will succeed.

The

The animalcula are infinitely smaller than spermatic animals, and of a very different shape; the truth of which every accurate observer will soon be convinced of; whose curiosity may lead him to compare them, and he is persuaded they will find they are no way akin.

Having learnt from Mr. De Saussure, of Geneva, that he found one kind of these animalcula infusoria that increase by dividing across into nearly two equal parts, and that the infusion was made from hemp-feed, he procured a quantity of this feed, some of it he put into New River water, some into distilled water, and some into very hard pump water; the result was, that in proportion to the heat of the weather, or the warmth in which they were kept, there was an appearance of millions of minute animalcula in all the infusions; and, some time after, some oval ones made their appearance; these were much larger than the first, which still continued; these wriggled to and fro in an undulatory motion, turning themselves round very quick all the time that they moved forwards.

Mr. Ellis found out, by mere accident, a method to make their fins appear very distinctly, especially in the larger kind of animalcula, which are common to most vegetable infusions, such as the terebella. This has a longish body, with a cavity or groove at one end, like a gimlet: by applying a small stalk of the horseshoe geranium; (or geranium zonale of Linnæus) fresh broken, to a drop of water in which these animalcula are swimming, we shall find that they will become torpid instantly, contracting themselves into an oblong oval shape, with their fins extended like so many bristles all round their bodies. The fins are

in length about half the diameter of the middle of their bodies. Before he discovered this expedient, he tried to kill them by different kinds of salts and spirits; but though they were destroyed by this means, their fins were so contracted, that he could not distinguish them in the least. After lying in this state of torpidity for two or three minutes, if a drop of clean water be applied to them, they will recover their shape, and swim about immediately, rendering their fins again invisible.

It is one of the wonders of the modern philosophy to have invented means for bringing creatures, so imperceptible as the various animalcula, under our cognizance and inspection. One might well have deemed an object that was a thousand times too little to affect our sense, as perfectly removed from human discovery; yet we have extended our sight over animals to whom these would be mountains. In reality, the greater number of microscopic animalcula are of so small a size, that through a lens, whose focal distance is the tenth part of an inch, they only appear as so many points; that is, their parts cannot be distinguished, so that they appear from the vertex of that lens under an angle not exceeding the minute of a degree. If we investigate the magnitude of such an object, it will be found nearly equal to $\frac{1}{100000}$ of an inch long. Supposing, therefore, these animalcula to be of a cubic figure, that is, of the same length, breadth, and thickness, their magnitude would be expressed by the cube of the fraction $\frac{1}{100000}$, that is, by the number $\frac{1}{100000000000000}$, that is, each animalculum is equal to so many parts of a square inch. This contemplation of animalcula has rendered the idea of indefinitely small bodies very familiar to us; a mite was formerly thought the limit of littleness, but we are not now surprized to be

be told of animals many millions of times smaller than a mite; for there are some animalcula so small, that, upon calculation, the whole earth is not found large enough to be a third proportional to these little animals, and the whale in the ocean.* These considerations are still further heightened, by reflecting on the internal structure of animalcula, for each must have all the proportion, symmetry, and adjustment of that organized texture, which is indispensibly necessary for the several functions of life, and each must be furnished with proper organs, tubes, &c. for secreting the fluids, digesting it's food, and propagating it's species.

Having thus given a general idea of the properties of animalcula, we now proceed to describe the various individuals, following the arrangements of O. F. Müller,† and giving the reader the discriminating characters by which he has distinguished them, abridging, enlarging, or altering the descriptions, to render them in some instances more exact, in others less tedious, and upon the whole I hope, more interesting to the reader.

A METHODICAL DIVISION OF THE ANIMALCULA INFUSORIA.

I. Those that have no external organs.

1. Monas : punctiforme. A mere point.

2. Proteus : mutabile. Mutable.

3. Volvox :

* Cyclopædia Britannica, Art. Animalcule.

† Müller Animalcula Infusoria, Fluviatilia et Marina.

3. Volvox: sphæricum. Spherical.
4. Enchelis: cylindraceum. Cylindrical.
5. Vibrio: elongatum. Long.

* Membranaceous.

6. Cyclidium: ovale. Oval.
7. Paramæcium: oblongum. Oblong.
8. Kolpoda: finuatum. Sinuous.
9. Gonium: angulatum. With angles.
10. Burfaria. Hollow like a purse.

II. Those that have external organs.

* Naked, or not inclosed in a shell.

1. Cercaria: caudatum. With a tail.
2. Trichoda: crinitum.
3. Kerona: corniculatum. With horns.
4. Himantopus: cirratum. Cirrated.

5. Leu-

5. *Leucophra* : ciliatum undique. Every part ciliated.

6. *Vorticella* : ciliatum apice. The apex ciliated.

* Covered with a shell.

7. *Brachionus* : ciliatum apice. The apex ciliated.

I. MONAS.

Vermis inconspicuus, simplissimus, pellucidus, punctiformis.
An invisible,* pellucid, simple, punctiform worm.

1. *Monas Termo*.

Monas gelatinosa. Gelatinous *Monas*.

Animalcules femblable a des points, spall. op. phys. I. p.
Bullæ continuo motu, Bonanni obs. p. 174.

Among the various animalcula which are discovered by the microscope, this is the most minute, and the most simple; a small jelly-like point, eluding the powers of the compound microscope, and being but imperfectly seen by the single; these, and some others of the mona kind, are so delicate and slender, that it is no wonder they often escape the sight of many who have examined infusions with attention; in a full light they totally disappear

* By invisible we only mean that they are too small to be discerned by the naked eye.

disappear, their thin and transparent forms blending as it were with the water in which they swim.

Small drops of infused water are often so full of these, that it is not easy to discover the least empty space, so that the water itself seems changed into another substance less transparent, but consisting of an innumerable number of globular points, thick sown together. In this a motion may be perceived, something similar to that which is observed when the sun's rays shine on the water, the animalcula being violently agitated, or in a commotion like unto a hive of bees. It is very common in ditch water, and in almost all infusions, both of animal and vegetable substances.

2. Monas Atomus.

Monas albida puncto, variabili instructa, Plate XXV. Fig. 1.
White mona, with a variable point.

This animalculum appears as a white point, which, when it is highly magnified, is somewhat of an egg shape; the smaller end is generally marked with a black point, the situation of this is sometimes varied, and found at the other end of the animalculum; sometimes two black points are to be seen crossing the middle of the body.

It was found in sea water that had been kept the whole winter; it was not, however, very fetid; there were no other animalcula in the same water.

3. Monas

3. *Monas Punctum.*

Monas nigra. A black mona.

A very minute point, solid, opaque and black, round and long. They are dispersed in the infusion, and move with a slow wavering motion; were found in a foetid infusion of pears.

4. *Monas Ocellus.*

Monas hyalina puncto centrali notata. Transparent like talc, with a point in the middle.

The margin black, and a black point in the middle; it moves irregularly, is found in ditches covered with conferva, and frequently with the *cyclidium milium*.

5. *Monas Lens.*

Monas hyalina. Transparent mona, of a talcy appearance.

This is among the number of the smaller animalcula, nearly of a round figure, and so pellucid, that it is not possible to discover the least vestige of intestines. Though they may often be seen separate, yet they are more generally collected together, forming a kind of vesicular or membranaceous mass. Contrary to the custom of other animalcula, they seek the edges of the evaporating water, the consequence of which is almost immediate death. When the water is nearly evaporated, a few dark shades are perceived, probably occasioned by the wrinkling of the body.

3 M

A flow

A slow tremulous motion, confined to one spot, may be perceived at intervals; this in a little time becomes more lively, and soon pervades the whole drop.

It's motions are, in general, very quick; two united together may sometimes be seen swimming among the rest; while in this situation they have been mistaken by some writers for a different species, whereas it is the same generating another by division.

It is to be found in all water, though but seldom in that which is pure; they are in great plenty in the summer in ditch water, also in infusions of animal or vegetable substances, made either of fresh or salt water, myriads being contained in a drop; numbers, of various sizes, are to be found in the filth of the teeth.

The animalcula of this and the first species are so numerous as to exceed all calculation, though they are contained in a very confined space.

6. Monas Mica.

Monas, circulo notata. Mona, marked with a circle.

This lucid little point may be discovered with the third lens of the common single microscope, when the magnifying power is increased; it appears either of an oval or spherical figure, for it assumes either at pleasure. It is transparent, and has a small ellipse inscribed as it were within it's circumference; this ellipse is moveable, being sometimes in the middle, sometimes a little towards the fore-part, at others nearer the hind-part.

There is a considerable variety in its motions ; it often turns round for a long time in the same place ; an appearance like two kidneys may sometimes be perceived in the middle of the body, and the animalculum is beautifully encompassed with a kind of halo, arising, most probably, from invifible and vibrating hairs.

They are to be found in the purest waters.

7. *Monas Tranquilla*.

Monas ovata, hyalina, margine nigro. Egg-shaped, transparent mona, with a black margin.

These animated points seem to be nearly fixed to one spot, where they have a vacillatory motion. They are frequently surrounded with a halo, and differ in their figure, being sometimes rather spherical, at others quadrangular. The black margin is not always to be found, and sometimes one would almost be tempted to think it had a tail. It is found in urine which has been kept for a time. The urine is covered, after it has remained in the vessel, with a dark-coloured pellicule, in which these animals live : although the urine was preserved for several months, no new animalcula were observed therein. It has been already shewn, that a drop of urine is in general fatal to other animalcula, yet we find that it has animated beings of a peculiar kind, appropriated to, and living in it.

8. *Monas Lamellula*.

Monas, hyalina compressa. Flat transparent monas.

This is mostly found in salt water. It is of a whitish colour, more than twice as long as it is broad, transparent, with a dark margin, the motion vacillatory; it often appears as if double.

9. *Monas Pulvisculus*.

Monas hyalina, margini virente. Transparent mona, with a green margin.

Little spherical pellucid grains, of different sizes, the circumference green, a green bent line passes through the middle of some, probably indicating that they are near separating, or dividing, into two distinct animalculum; sometimes three or four, at others six and seven, or even more, are collected together. They rove about with a wavering motion, and are mostly found in the month of March in marshy grounds.

10. *Monas Uva*.

Monas hyalina gregaria. Transparent gregarious monas.

It is not easy to decide on the nature of these little assemblages of corpuscles, which sometimes consist of five, at other times of four, and frequently of many more; the corpuscles are of different sizes, according to the number collected in one group. When
collected

collected in a heap, the only motion they have is a kind of revolution, or rolling round. The smaller particles separate from the larger, often dividing into as many portions as there are constituent particles in the group; when separated, they move about with incredible swiftness.

To try whether this was a group of animalcula collected together by chance, or whether it was their natural state to be thus grouped together, the following experiment was made. A single corpuscle was taken the moment it was separated from the heap, and placed in a glass by itself; it soon increased in size, and when it had attained nearly the same bulk as the group from which it was separated, the surface began to assume a wrinkled appearance, which gradually changed till it became exactly similar to the parent group. This new-formed group was again decomposed, like the preceding one, and in a little time the separated particles became as large as that from which they proceeded.

It is found in a variety of infusions.

II. PROTEUS.

Vermis inconspicuus, simplicissimus, pellucidus, mutabilis. An invisible, very simple, pellucid worm, of a variable form.

11. Proteus Diffluens.

Proteus in ramulos diffluens, Fig. 2 and 3, Plate XXV. Proteus, branching itself out in a variety of directions.

A very

A very singular animalculum, appearing only as a grey mucous mass; it is filled with a number of black globules, of different sizes, and is continually changing its figure. Being formed of a gelatinous pellucid substance, the shape is easily altered, and it pushes out branches of different lengths and breadths. The globules which are within divide and pass immediately into the new-formed parts, always following the various changes of form in the animalcula. The changes that are observed in the form of this little creature, do not arise from any extraneous cause, but are entirely dependent on its internal powers.

It is to be met with but very seldom; the indefatigable Muller only saw it twice, although he examined such an immense variety of infusions.

It is to be found in fenny situations.

12. *Proteus Tenax*.

Proteus in spiculum diffuens, Fig. 4 and 5, Plate XXV.
Proteus, running out into a fine point.

A gelatinous pellucid body, stored with black molecules; it changes its form like the preceding, but always in a regular order, first extending itself out in a strait line, the lower part terminating in an acute bright point, without any intestines, and the globules being all collected in the upper part, it next draws the pointed end up towards the middle of the body, swelling it into a round form. The contraction goes on for some time, after which the
lower

lower part is swelled out as it is represented in Fig. 4; the point is afterwards projected from this ventricose part. It passes through five different forms before it arrives at that which is seen at Fig. 4. It scarcely moves from one spot, only bending about sideways. It is to be found in river water, where the *C. nitida* grows,—a the tail, c the head, d the protuberant swelling.

III. VOLVOX.

Volvox inconspicuus simplicissimus, pellucidus, sphaericus.
An invisible, very simple, pellucid, spherical worm.

13. *Volvox Punctum.*

Volvox sphaericus, nigricans, puncto lucido. Spherical, of a black colour, with a lucid point.

A small globule; one hemisphere is opaque and black, the other has a pellucid crystalline appearance; a vehement motion is observable in the dark part. It moves in a tremulous manner, and often passes through the drop, turning round as if upon an axis. Many may be often seen joined together in their passage through the water, they sometimes move as in a little whirlpool, and then separate. It is found in great numbers on the surface of foetid sea water.

14. Vol-

14. *Volvox Granulūm.*

Volvox sphæricus, viridis, periphæria hyalina. Sphærical and green, the circumference of a bright colour.

There seems to be a kind of green opake nucleus in this animalculum; the circumference is transparent. It is to be found generally in the month of June, in marshy places; it moves but slowly.

15. *Volvox Globulus.*

Volvox globosus, postice subobscurus. Globular volvox, the hinder part somewhat obscure.

This globular animalculum is ten times larger than the monalens; it verges sometimes a little towards the oval in its form. The intestines are just visible, and make the hinder part of the body appear opake; it has commonly a slow fluttering kind of motion, but if it is disturbed the motion is more rapid.

It is found in most infusions of vegetables.

16. *Volvox Pilula.*

Volvox sphæricus, interaneis immobilibus virescentibus. Small round volvox, with immoveable green intestines:

This is a small transparent animalculum; its intestines are immoveable, of a green colour, and are placed near the middle of
the

the body, the edges often yellow ; a small obtuse incision may be discovered on the edge, which is, perhaps, the mouth of the animalculum. This little creature appears to be encompassed with a kind of halo, or circle. If this is occasioned by the vibratory motion of any fringe of hairs, they are invisible to the eye, even when assisted by the microscope.

It seems to have a kind of rotatory motion, at one time slow, at another quick, and is to be found in water where the *lemna minor* grows, sometimes as late as the month of December.

17. *Volvox Grandinella*.

Volvox sphaericus, opacus, interaneis immobilibus. Spherical and opaque, with immoveable intestines.

This is much smaller than the preceding, and is marked with several circular lines ; no motion is to be perceived among the interior molecules. It sometimes moves about in a strait line, sometimes its course is irregular; at others it keeps in the same spot, with a tremulous motion.

18. *Volvox Socialis*.

Volvox sphaericus, *moleculis crystallinis*, *æqualibus distantibus*. Spherical *volvox*, with crystalline molecules, placed at equal distances from one another.

When very much magnified, this animalculum seems to have some relation to the vorticella socialis, as seen with the naked eye. It consists of crystalline molecules, disposed in a sphere, and filling up the whole circumference; they are all of an equal size. Whether they are included in a common membrane, or whether they are united by one common stalk, as in the vorticella socialis, has not been discovered. We are also ignorant of the exact figure of the little particles of which it is composed; when a very large magnifying power is used, some black points may be discerned in the center of the crystalline molecules. The motion is sometimes rotatory, sometimes from right to left, and the contrary. It is found where the chara vulgaris has been kept.

19. Volvox Sphæricula.

Volvox sphæricus, moleculis simularibus rotundis. Spherical volvox, with round molecules.

This spherule is formed of pellucid homogeneous points, of different sizes. It moves slowly about a quarter of a circle from right to left, and then back again from left to right.

20. Volvox Lunula.

Volvox hemisphæricus, moleculis simularibus lunatis. An hemispherical volvox, with lunular molecules. Fig. 7, Plate XXV.

Is a small roundish transparent body, composed of innumerable molecules, homogeneous, pellucid, and of the shape of the moon in it's first quarter, without any common margin.

It is in a continual twofold motion; the one of the whole mass turning slowly round, the other of the molecules one among the other. They are found in marshy places in the beginning of spring.

21. *Volvox Globator.*

Volvox sphaericus membranaceus. Spherical membranaceous volvox.

This is a transparent globule, of a greenish colour; the fœtus is composed of smaller greenish globules. It becomes whiter and brighter with age, moves slowly round it's axis, and may be perceived by the naked eye.

But to the microscope the superficies of this pellucid membrane appears covered with molecules, as if it were granulated, which has occasioned some observers to imagine it to be hairy; the round pellucid molecules that are fixed in the center are generally largest in those that are young. The exterior molecules may be wiped off, leaving the membrane naked.

When the young ones are of a proper size, the membrane opens, and they pass through the fissure; after this, the mother melts away. They sometimes change their spherical figure, the superficies being flattened in different places.

Most authors speak of finding eight lesser globules within the larger; but Muller says, that he has counted thirty or forty of different sizes. This wonderful incapsulation of it's progeny is well known; indeed it often exhibits itself big with children and grandchildren.

Leeuwenhoeck was the first who noticed this curious animalculum, and depicted it; a circumstance which has not been mentioned by Baker and other microscopic writers who have described it. It may be found in great plenty in stagnant waters in spring and summer, and in infusions of hemp-seed and tremella.

It is thus described by Mr. Baker. This singular minute water animal, seen before the microscope, appears to be exactly globular, without either head, tail, or fins. It moves in all directions, forwards or backwards, up or down, rolling over and over like a bowl, spinning horizontally like a top, or gliding along smoothly without turning itself at all. Sometimes it's motions are very slow, at other times very swift; and when it pleases it can turn round as upon an axis very nimble, without moving out of it's place. The body is transparent, except where the circular spots are placed, which are probably it's young. The surface of the body in some is as it were dotted all over with little points, and in others as if granulated like shagreen. Mr. Baker thought also that in general it appeared as if it was set round with short moveable hairs.

By another writer they are thus described. These animalcula are at first very small, but grow so large as to be discerned with the naked eye; they are of a yellowish green colour, globular figure,

figure, and in substance membranaceous and transparent; in the midst of this substance several small globes may be perceived; each of these are smaller animalcula, which have also their diaphanous membrane, and contain within themselves still smaller generations, which may be distinguished by the assistance of very powerful glasses. The larger globules may be seen to escape from the parent, and then increase in size, as we have already observed.

22. Volvox Morum.

Volvox membranaceus orbicularis, centro moleculis sphaericis viridibus. Membranaceous orbicular, with spherical green molecules in the center.

This animalculum has some resemblance to the volvox uva, but is sufficiently distinguished by the surrounding bright orbicular membrane. The middle part is full of clear green globules. The globules seldom move, though a quivering motion may sometimes be perceived at the center. It has a slow rotatory motion, and is found amongst the lemna, in the months of October and December.

23. Volvox Uva.

Volvox globosus, moleculis sphaericis virescentibus nudis. Globular volvox, composed of green spherical globules, which are not inclosed in a common membrane.

This

This animalculum seems to be a kind of medium between the volvox pillula and the gonium pectorale, being like the one composed of green spherules, and in form resembling the other.

It consists of a congeries of equal globules of a greenish colour, with a bright spot in the middle; the whole mass is sometimes of a spherical form, sometimes oval, without any common membrane; a kind of halo may be perceived round it, but whether this is occasioned by the motion of any invisible hairs has not been discovered. The mass generally moves from right to left, and from left to right; scarce any motion can be discovered in the globules themselves. It was found in the month of August, in water where the *lemna polyrrhiza* was growing. Two masses of these globules have been seen joined together. They contain from four to fifty of the globules, of which a solitary one may now and then be found.

24. Volvox Vegetans.

Volvox ramulis simplicibus & dichitomis, rosula globulari terminatis. A volvox with simple dichitinous branches, terminating in a little bunch of globules.

It consists of a number of floccose opaque branches, which are invisible to the naked eye; at the apex of these there is a little congeries of very minute oval pellucid corpuscles. Muller at first thought it to be a species of microscopic and river *fertularia*; but afterwards he found the bunches quitting the branches, and swimming about in the water with a proper spontaneous motion. Many old branches were found deserted of their globules, while
the

the younger branches were furnished with them. It was found in river water in November 1779 and 1780.

IV. ENCHELIS.

Vermis inconspicuus, simplicissimus, cylindraceus. An invifible, fimple, cylindric worm.

25. Enchelis Viridis.

Enchelis fubcylindrica, antice oblique truncata. Green enchelis, of a fubcylindric figure, the fore-part truncated.

This is an opaque, green, fubcylindric animalculum, with an obtufe tail, the fore-part terminating in an acute truncated angle; the inteflines obfcure and indiftinct.

It is continually varying in it's motion, turning from right to left.

26. Enchelis Punctifera.

Enchelis viridis, fubcylindracea, antice obtufa, poftice acuminata, Fig. 8, Plate XXV. Green enchelis, fubcylindric, the fore-part obtufe, the hinder-part pointed.

It is an opaque animalculum, of a green colour; there is a fmall pellucid spot in the fore-part a, in which two black points may be feen; a kind of double band, c c, croffes the middle of the body. The hinder part is pellucid and pointed; an incifion
is

is discoverable at the apex of the fore-part, which seems to be the mouth. When in motion, the whole of it appears opake and green. Is found in marshes.

27. *Enchelis Defes.*

Enchelis viridis, cylindrica, subacuminata gelatinosa. Green, cylindrical, gelatinous, the ends somewhat pointed.

The body is round, the colour a very dark green, so that it is quite opake; the fore-part is bluntly rounded off, the hinder part is somewhat tapering, but finishes with a rounded end. From it's opacity, no internal parts can be discovered; there is a degree of transparency near the ends.

It is exceeding idle, moving very slowly; to be found, though rarely, in an infusion of *lemnæ*.

28. *Enchelis Similis.*

Enchelis obovato-opaca, interaneis mobilibus. *Enchelis* of an egg-shape, opake, with moveable intestines.

It is an opake body, with a pellucid margin; both extremities are obtuse, but the upper one much more so than the under one; it is filled with moveable spherules. It's motion is generally quick, either to the right or the left; it is probably furnished with hairs, because, when moving rapidly, the margin appears striated. It is found in water that has been kept for months.

29. *En-*

29. *Enchelis Serotina*.

Enchelis ovato-cylindracea, *interaneis immobilibus*. *Enchelis* partly oval, partly cylindrical, the interior parts immoveable.

An oval animalculum, round, the fore-part smaller than the hind-part, the margin of a black colour; it is replete with grey vesicular molecules, and moves slowly.

30. *Enchelis Nebulosa*.

Enchelis ovato-cylindracea, *interaneis manifestis mobilibus*. Oval and cylindric *enchelis*, with visible moveable intestines.

The body is shaped like an egg, the fore-part narrow, and often filled with opaque confused intestines; in moving, it elevates the fore-part of the body. It is found in the same water as the *cyclidium glaucoma*, but is three times larger, and an hundred times more scarce.

31. *Enchelis Seminulum*.

Enchelis cylindracea æqualis. *Enchelis* equally cylindric.

It is a cylindrical animalculum, twice as long as it is broad, the fore and hind-part of the same size; the intestines in the fore-part are pellucid, those in the hinder-part obscure. It moves by ascending and descending alternately. It may be seen sometimes

swimming about with the extremities joined together. Found in water that has been kept for some days.

32. *Enchelis Intermedia*.

Enchelis cylindracea, hyalina, margine nigricante. Cylindrical *enchelis*, transparent, with a blackish margin.

This animalculum forms an intermediate kind between the *monas punctum*, the *enchelis feminulum*, and the *cyclidium milium*. It is one of the smallest among the animalcula. The body is transparent, it has no visible intestines, the fore and hind-part are of an equal size, the edge of a deeper colour than the rest of the body; a point is to be seen in the middle of some of them, in others it is as if a line passed through the middle.

33. *Enchelis Ovulum*.

Enchelis cylindrico-ovata hyalina. Egg-shaped transparent *enchelis*.

A transparent, round, egg-shaped animalculum; nothing is discovered within side, even by the third magnifier; but with an increased power some long foldings may be seen on the superficies, and here and there a few bright molecules.

34. *Enchelis Pirum*.

Enchelis inverse conica, postice hyalina. Pear-form *enchelis*, the hinder-part transparent.

This

This enchelis is lively and pellucid, the fore-part is protuberant, and filled with molecules, the hinder-part smaller and empty; it has moveable molecular intestines. Its motion is rapid, passing backwards and forwards through the diameter of the drop. When at rest, it seems to have a little swelling, or tubercle, on the middle of the body.

35. Enchelis Tremula.

Enchelis ovato-cylindracea, gelatina. Oval enchelis, cylindrical, gelatinous.

This is also to be placed amongst the most minute animalcula; the end of it is rather pointed, and has a tremulous motion; it almost induces one to think it has a tail. Two of these little creatures may at times be perceived to adhere together. It was found in an infusion with the paramæcia aurelia, and many other animalcula.

36. Enchelis Constricta.

Enchelis obovata, crystallina, medio coarctata. Suboval enchelis, crystalline, with a stricture in the middle.

An animalculum of an oval shape, the middle part drawn in, as if a string was tied round it. It is of a very small size, and is found in salt water.

37. *Enchelis Pulvisculus.*

Enchelis eliptica, interaneorum congerie viridi. Of an elliptic shape, with a congeries of green intestines.

It is a round animalculum, pellucid, the fore-part obtuse, the hind-part rather sharp, marked with green spots; myriads may sometimes be seen wandering about in one drop; it is found among the green matter on the sides of the vessels in which water has been kept for some time.

38. *Enchelis Fufus.*

Enchelis cylindracea, utraque extremitate angustiore truncata. Cylindrical enchelis, both ends truncated.

The body is round and transparent, the fore and hind-part smaller than the rest of the body, and equally so, the ends a little truncated. In the inside a long and somewhat winding intestine, a sky-coloured bright fluid, and some black molecules transversely situated, may be discerned.

It's motions are languid; was found in pure water.

39. *Enchelis Fritillus.*

A cylindric enchelis, the fore-part truncated.

This

This is one of the most transparent animalcula; the hinder-part of an obtuse convexity, the fore-part truncated. Muller suspects that there is a rotatory organ in the fore-part. No intestines can be seen. It runs backwards and forwards through the drop in a diametrical line, with a wavering motion; sometimes turns round for a moment, but presently enters on its usual course. Is found in an infusion of grass and hay.

40. *Enchelis Caudata*.

Enchelis elongata, apice obtusa, postice in caudam hyalinam attenuata, Fig. 9, Plate XXV. *Enchelis* with a long body, the fore-part obtuse, the hinder-part diminishing into a kind of tail.

The body is of a grey colour; pellucid, with globular molecules divided from each other, and dispersed through the whole body; the fore-part, a, thick and obtuse, the hind-part, b, crystalline and small, the end truncated. It is but seldom met with.

41. *Enchelis Epistomium*.

Enchelis cylindrico-elongata, apice gracili subgloboso. *Enchelis* with a long cylindric body, the fore-part slender and roundish.

It is among the smaller animalcula; the body is cylindrical and bright, the hind-part obtuse, the fore-part smaller, and terminating in a globule; a black line may now and then be perceived down the middle of it.

42. *Enchelis Gemmata.*

Enchelis cylindracea, serie globulorum duplici, in collum hyalinum producta. *Enchelis* with a cylindrical body, the upper part prolonged into a transparent neck, a double series of globules running down the body. It's motion is slow, and generally in a straight line; it is found in ditch-water where the *lemnath* thrives.

43. *Enchelis Retrograda.*

Enchelis hyalina, antice angustata, apice globulari. Transparent *enchelis*, the fore-part rather smaller, and terminating in a small globule, Fig. 11 and 12, Plate XXV.

It has a gelatinous transparent body; no visible intestines, though a pellucid globule is discoverable near the hinder part; the body is thickest in the middle, and grows smaller towards each end. It generally moves side-ways, sometimes in a retrograde manner; and if it is obstructed in it's motion, draws itself up as it is represented at Fig. 11.

44. *Enchelis Festinans.*

Enchelis cylindrica oblonga, obtusa, antice hyalina. Oblong cylindrical *enchelis*; the ends obtuse, the fore-part transparent.

The

The body is round, of an equal size throughout, and both ends obtuse; more than half the length is without any visible intestines, the lower end full of vesicular, pellucid, minute globules; a large globular vesicle is also to be found in the fore-part; it moves quickly from one side to the other, in a vacillatory manner. It was found in sea-water.

45. *Enchelis Farcimen.*

Enchelis cylindracea curvata utrinque truncata. A cylindric *enchelis*, crooked and truncated at both ends.

The body of this is cylindrical, about four times longer than it is wide, even, truncated at both ends, the intestines opaque, and not to be distinguished; it turns the extremities opposite ways, so as to form the figure of an S. It is to be found in water that has stood for some time, though but seldom. Joblot found it in an infusion of blue bottles; it moves in an undulatory manner, but very slowly.

46. *Enchelis Index.*

Enchelis inverse conica, apicis altero angulo producto. *Enchelis* in the form of an inverted cone, one edge of the apex produced out so as to form an angle with the other part.

The body rather opaque, of a grey colour, and of a long conical figure; the lower end obtuse, the fore-part thick, one side of this part projecting like a finger from the edge; two very small projections proceed also sometimes from the lower end.

This animalculum has the power of retracting these projections, and making both ends appear obtuse. It moves about but slowly, and was found in water with the *lemna minor*.

47. *Enchelis Truncus*.

Enchelis cylindrica, subcapitata. Fig. 10. Plate XXV. Cylindrical *enchelis* with a kind of head.

This is the largest of this kind of animalcula; the body is cylindrical, mucose, grey, long and rather opaque, the fore-part globular, the hind-part obtuse. Something like three teeth (c) may be sometimes seen to proceed from one of the sides; it can alter its shape considerably. Globules of different sizes may be seen within the body. It rolls about slowly from right to left.

48. *Enchelis Larva*.

Enchelis elongata, medio papillula utrinque notata. A long *enchelis*, with two little nipples projecting from the middle of the body, one on each side.

It is long, round, and filled with grey molecules; the fore-part is obtuse and pellucid; a kind of neck, or small contraction, is formed at some little distance from this end. The lower part pointed, about the middle of the body there are two small projections.

49. *En-*

49. *Enchelis Spatula*.

Enchelis cylindrica striata, apice hyalino-spatulata. A cylindrical striated *enchelis*, the fore-part transparent, and of the shape of a spatula.

This animalculum is perfectly cylindrical, very pellucid, of a crystalline appearance; it is marked with very fine longitudinal furrows, and has generally two transparent globules, one placed below the middle, the other near the extremity of the body; on the other side are five smaller ones, which are oval. The top is dilated, with the corners rounded like the spatula of the apothecaries. It has a wavering kind of motion, folding the spatula variously, yet retaining the form in general. Muller mentions his seeing it once draw the spatula into the body, and keep it there for two hours, when it again appeared.

50. *Enchelis Pupula*.

A cylindric *enchelis*, the fore-part papillary.

The fore-part is protuberantly round, and rather opaque, the hind-part pellucid, both extremities obtuse, furnished with a papillary finger-shaped head, the hinder-part marked with a transparent circle, or circular aperture. The fore-part filled up with moveable molecules, which are more scarce in the hinder-part. It has a rotatory motion on a longitudinal axis, and moves through the water in an oblique direction. It is to be found in dunghill-water in November and December.

51. *Enchelis Pupa.*

Enchelis ventricoso-cylindrica, apice in papillam producta. *Enchelis* forming a kind of ventricose cylinder, with a small nipple proceeding from the apex.

It is not unlike the preceding animalculum, but is much larger; the anterior end not so obtuse, the nipple gradually formed from the fore-part, all but this end is opaque, and filled with obscure particles: it has no transparent circle, as was observed in the *enchelis pupula*. It is exceeding flothful.

V. *VIBRIO.*

Vermis inconspicuus, simplicissimus, teres, elongatus. An invifible worm, very fimple, round, and rather long.

52. *Vibrio Lineola.*

Vibrio linearis minutissimus. Very small linear vibrio.

This is one of the most minute animalcula, surpassing in slenderness the *monas termo*. The greatest magnifier exhibits little more than a tremulous motion of myriads of little oblong obscure points. In a few days it almost fills the whole substance of the water in vegetable infusions.

53. *Vibrio*

53. *Vibrio Rugula.*

Vibrio linearis flexuosus. *Vibrio* like a bent line.

Myriads of this species may be found; it is between the *vibrio lineola* and the *vibrio undula*.

It appears as a little line, which is sometimes drawn up in an undulated shape, and moves backwards and forwards in a strait line, often without bending the body at all.

54. *Vibrio Bacillus.*

Vibrio linearis, æqualis utrinque truncata. Linear *vibrio*, equally truncated at both ends.

This is an exceeding small creature, but visible with the third lens; in a certain position of the light transparent. It is gelatinous, and not half so large as the *monas lens*, though six, and sometimes ten times longer; it is every-where of an equal size, and has no visible intestines; its action is languid, the serpentine flexures of the body are with great difficulty perceived.

Muller made two infusions of hay in the same water, and at the same time in the one he put the hay whole, in the other it was cut in small pieces; in the first there was none of the *vibrio bacillus*, but many of the *monas lens* and *kolpoda cucullus*; in the latter, many of *vibrio bacillus*, and few of the *monæ*.

55. *Vibrio Undula.*

Vibrio filiformis flexuosus. A filiform flexuous vibrio.

A perfect undulating little line, round, gelatinous, without any visible intestines. It is never strait; when at rest it resembles the letter V, when in motion the letter M, or a bending line like that which geese form in their flight through the air; its motions are so rapid, that the eye can scarce follow them. It generally rests upon the top of the water, sometimes it fixes itself obliquely by one extremity, and whirls itself round.

This is the little creature that Leeuwenhoeck says exceeds in slenderness the tail of the animalculum seminale, which he has described in Fig. 5, Epif. Phys. 41, being an hundred times less than a mustard-seed, and on which he makes the following very just observation: That as these very small animalcula can contract and variously fold their little tails, we must conclude that tendons and muscles are as necessary to them as to other animals; if to this we add the organs of sensation, and those of the intestines, the mind is lost in the astonishment which arises from the impression of infinite, in the indefinitely small.

56. *Vibrio Serpens.*

Vibrio filiformis, ambagibus in angulum obtusum productis. A filiform vibrio, the windings or flexures obtuse.

A slen-

A slender gelatinous little animal, in the form of a long serpentine line, all the bendings being nearly equal in size, and at equal distances; it generally moves in a strait line; an intestine may be discovered down the middle. It is to be found in river water, but is not commonly to be met with.

57. *Vibrio Spirillum.*

Vibrio filiformis, ambagibus in angulum acutum tornatis. Filiform vibrio, twisted something like a spiral wire, or corkscrew; the bending acute.

It is an exceeding minute singular little creature, twisted in a spiral form; the shape of these bendings remains the same even when the animal is in motion, not occasioned by any internal force, but are it's natural shape. It moves generally in a strait line, vibrating the hind and fore-part. It was found in 1782, in an infusion of the *fonchi arvensis*.

58. *Vibrio Vermiculus.*

Vibrio tortuosus gelatinus. This little vibrio is twisted and gelatinous.

The body is white, or rather of a milky appearance, cylindric, long, the apex obtuse, rather growing smaller, and twisted towards the hind-part. It's motion is languid and undulatory, like that of the common worm; it sometimes moves quicker, but with seeming labour. When it bends itself alternately from one side to the other, a black long line may be discovered, sometimes

whole, sometimes broken : when at rest, it occasionally twists into various folds.

It may be observed easily with the first lens of the single microscope, and is probably the same animalculum mentioned by Leeuwenhoeck in all his works, as found in the dung of frogs, and in the spawn of the male libellula. It is to be found in marshy water in November, though but feldom.

59. *Vibrio Intestinum.*

Vibrio gelatinosus, teres, antice angustatus. This vibrio is gelatinous, round, the fore-part small.

It is cylindric, milk-coloured, and slender towards the top, both ends obtuse; no traces of intestines to be discovered, though four or five spherical eggs are perceived at the extremity of the hind-part. It can draw the fore-part so much inwards as to give it a truncated and dilated appearance, something like a spatula. Its motion is slow and progressive. They are found in marshy waters.

60. *Vibrio Bipunctatus.*

Vibrio linearis, æqualis, utraque extremitate truncata, globulis binis mediis. Linear vibrio, of an equal size throughout, both ends truncated, and two small globules in the middle of the body.

It is of a small size, and rather less than the following animalculum, the body of a pellucid talc-like appearance, the fore and
hind-

hind-part truncated; in the middle are two (sometimes there is only one) pellucid globules, placed lengthways. It most commonly moves forwards in a strait line; it's movements are flow. It was found in stinking salt water.

61. *Vibrio Tripunctatus.*

Vibrio linearis, utrinque attenuatus, globulis tribus, extremis minoribus. Linear vibrio, both the ends smaller than the middle, furnished with three globular points, the two which are at the extremities being smaller than that at the middle.

The body is pellucid, talsey, each of the ends rather tapering; furnished with three pellucid globules, the middle one is the largest, the space between these globules is generally filled with a green matter; in some there is nothing of the green substance near the extremities, but only about the middle. It seldom moves far, and then it's motion is rectilinear, backwards and forwards.

62. *Vibrio Paxillifer.*

Vibrio flavescens paleis gregariis multifariam ordinatis, Fig. 13, 14, 15, Plate XXV. Yellow, gregarious, straw-like vibrio.

This is a wonderful animalculum, or rather a congeries of animalcula. It is invisible to the naked eye, and consists of a transparent membrane, with yellow intestines, and two or three visible points; they are generally found collected together in different parcels.

parcels, from seven to forty in number, and ranged in a variety of forms, sometimes in a strait line, as in Fig. 14, then forming the concave Figure 13, at others moving in a zig-zag direction, as in Fig. 15; when at rest, they are generally in a quadrangular form, and found in great plenty with the *ulva latissima*.

As this animalculum seems to have some affinity with the hair-like animal of Mr. Baker, I think the reader will be better pleased to see his description of it introduced in this place, than to have it raised into a new and distinct species.

This little animal is extremely slender, and not uncommonly one hundred and fifty times longer than broad. Its resemblance to an hair induced Mr. Baker to call it the hair-like insect. The body, or middle part, which is nearly strait, appears in some composed of such parallel rings as the windpipe of land animals consists of, but seems in others scaled, or rather made up of rings that obliquely cross each other. Its two ends are bent, or hooked, pretty nearly in the same degree, but in a direction contrary each to the other; and as no eyes can be discerned, it is difficult to judge which is the head or tail.

Its progressive motion differs from that of all animals hitherto described, for notwithstanding the body is composed of many rings and joints, it seems unable to bend them, or move directly forwards; but when it is inclinable to change its quarters, it can move from right to left, or left to right, and proceed at the same time backwards or forwards obliquely; and this it performs by turning upon one end as a center, and describing with the other the quarter of a circle, then it does the same with the other end,
and

and so alternately, whereby it's progression is in a diagonal line, or from corner to corner; as whoever will take the trouble to shift the points of a pair of compasses in that manner, may immediately be satisfied.

All it's motions are extremely slow, and require much patience and attention in the observer. It has neither feet, nor fins, nor hairs, but appears perfectly smooth and transparent, with the head bending one way, and the tail another, so as to be like a long Italic S; nor is any internal motion, or particularly opaque part, to be perceived, which may determine one to suppose it the stomach, or other of the intestines.

These creatures are so small, that millions of millions might be contained in an inch square. When viewed singly, or separated from one another, they are exceedingly transparent, and of a lovely green; but, like all other transparent bodies, when numbers of them are brought together they become opaque, and lose their green colour in proportion as the quantity increases, till at last they appear entirely black.

Notwithstanding the extreme minuteness of these animalcula, they seem to be fond of society; for on viewing for some time a parcel of them taken up at random, they will be seen to disperse themselves in a kind of regular order. If a multitude of them are put into a jar of water, they will form themselves into a regular body, and ascend slowly to the top, where, after they have remained some time exposed to the air, their green colour changes to a beautiful sky-blue. When they are weary of this situation,

they form themselves into a kind of rope, which slowly descends as low as they intend.

A small quantity of the matter containing these creatures having been put into a jar of water, it so happened, that one part went down immediately to the bottom, whilst the other continued floating on the top. After some time, each of these swarms of animalcula began to grow weary of it's situation, and had a mind to change it's quarters. Both armies, therefore, set out at the same time, the one proceeding upwards, and the other downwards; so that after some hours journey they met in the middle. A desire of knowing how they would behave on this occasion engaged the observer to watch them carefully, and to his surprize he saw the army that was marching upwards open to the right and left, to make room for those that were descending. Thus without confusion or intermixture, each held on it's way, the army that was going up marching in two columns to the top, and the other proceeding in one column to the bottom, as if each had been under the direction of wise leaders.

63. *Vibrio Lunula*.

Vibrio arcuatus, utraque extremitate æquali, Fig. 16. Bow-shaped vibrio, both ends of an equal size.

The body resembles much the shape of the moon at the first quarter; it is of a green colour, and has generally from seven to ten globules disposed lengthways; the smaller ones are of a very pale colour, a pale green vacuity may sometimes be seen in the middle: some little varieties may be observed amongst them, which

which are not easy to be described; it will be enough to have given the reader their general and distinguishing characteristics.

64. *Vibrio Verminus.*

Vibrio linearis compressus, antice quam postice angustior. Linear compressed vibrio, the fore-part narrower than the hind-part.

A round transparent animalculum, or rather a long crystalline membrane, the hind-part broader than the fore-part, the apex subtruncated, the base obtuse, no perceptible intestines, in the middle are two spherical vesicles, and a third towards the lower edge. It moves quickly, with an undulatory motion, backwards and forwards; they seem to be joined in a very singular manner, and are found in great plenty in salt water that had been kept some days, and was foetid.

65. *Vibrio Mallæus.*

Vibrio linearis basi globuli, apice linea transversa. A linear vibrio, with a globule at the base, and transverse line at the apex.

This is a white pellucid animalculum, resembling the letter T, with a globule affixed to the base.

It is in motion and at rest every moment alternately; when in motion it resembles the letter V, when at rest the letter T. They are found plentifully in spring water.

66. *Vibrio Acus.*

Vibrio linearis, colli, apice obtuso, cauda fetacea. Linear vibrio, with a neck, the upper extremity obtuse, the lower one terminating in a fetaceous tail.

This vibrio is of the shape of a sewing needle; the neck round, partly transparent, and marked in the middle with a red point; the trunk cylindrical, the edges obscure, the middle bright, and nearly of a triangular appearance, the tail is fine like a bristle. A motion may be observed in the inside of this little creature. It does not bend the body when in motion.

67. *Vibrio Sagitta.*

Vibrio sublinearis, colli, apice truncato atro, cauda fetacea. Somewhat linear in it's appearance, a well-marked neck, the apex truncated and open, the tail fetaceous.

The body is very long and flexible, broadest towards the middle, which is also filled with grey molecules; the fore-part is drawn out into a strait transparent neck, the upper end of it thick and black. The motion of this animalculum seems to be produced by the contraction and extension of the neck. It is found in salt water.

68. *Vibrio.*

68. *Vibrio Gordius*.

Vibrio æqualis, caudæ apice tuberculato. *Vibrio* of an equal size throughout, the tail terminated by a little tubercle.

A round animalculum; the fore-part for about one-sixth of the whole length is transparent, and furnished with a sky-coloured alimentary tube; the lower part is bright and pointed, the middle full of small globules; a small knob terminates the tail. Found in an infusion made with salt water.

69. *Vibrio Serpentulus*.

Vibrio æqualis utrinque subacuminatus. This *vibrio* is of an equal size, rather pointed at both ends.

It is very similar to the *vibrio anguillula*, differing principally in the shape of the ends, which in this are pointed. It does not adhere to objects by the pointed tail; it is furnished with a long row of the most minute points.

It's motion is serpentine, sometimes to be met with perfectly straight and still, and is found in infusions of vegetables after some weeks standing; it is of a whitish colour, the whole body is frequently convoluted, and drawn into different figures.

70. *Vibrio*

70. *Vibrio Coluber.*

Vibrio filiformis, feta-caudali geneculata. Filiform vibrio, the tail fetaceous, and bending up nearly to form a right angle with the body.

In this vibrio the mouth, the oesophagus, the molecules in the intestines, and the twisting thereof, are very conspicuous. The tail is exceeding small, and bent so as to form a considerable angle with the body. It is found in river water.

71. *Vibrio Anguillula.*

Vibrio æqualis subrigidus. Vibrio of an equal size throughout, and somewhat hard.

This animalculum may be divided into four varieties, if not distinct species, namely, the *anguillula aceti*, *glutinis farinosi*, *aquæ dulcis*, et *aquæ marini*.

Anguillula Aceti. Vinegar Eel.

Chaos redivivum, Lin. Syft. Nat. 1326.

Leeuwenhoeck Op. Omn. p. 3, n. 1, f. 1, c.

Joblot Obf. Micr. 1, p. 2, pl. 2.

Hook's Micr. p. 25, fig. 2.

Borelli Obf. Micr. 1, p. 7.

Power's

Power's Micr. Obs. p. 38.

Baker's Empl. for Micr. p. 10, fig. 8 and 9.

——— Micr. Expl. p. 81, pl. 5, fig. 10.

Adams Micr. Illuf. pl. 32, fig. 197, A, B, C, D.

Rozier Journal Physique, Mars 1775, Janv. & Mars 1776.

Spallanzani Opus, Phy. part 1, p. 83.

Anguillula Glutinis. Paste Ecl.

Chaos redivivum, Lin. Syst. Nat. 1326.

Ledermuller Micr.

Baker Micr. Exp. p. 82.

Roz. Journal Physique, Mars 1775, Mars 1776.

Adams Micr. Illuf.

The body is filiform, or like a thread, round, pellucid, replete with little grains in the middle, both extremities very pellucid and empty, the fore-part a little truncated, the hind-part terminating in a very short bristly point. It is the same in every age and size.

Anguillula Fluvialis.

Corculum vermiculo-fimile Lin. amæn (mund. invis).

Needham Micr. p. 99, pl. 5, fig. 7.

Baker Micr. Expl. p. 80, pl. 5, fig. 9.

— Anguille vulgaire, Rozier Journal Physique, 1775.

Mars, Nov. 1776.

Ibid, anguille du bled Rachitique.

Ibid, anguille du faux ergot.

Spallanz. Opusc. Phys. part 2, page 354, pl. 5, fig. 10.

The

The body of this is exceedingly transparent; no visible entrails, though a few transverse lines may be discovered on the body. It is sometimes, though rarely, furnished with a long row of little globules, and often with two small oval ones; the tail terminates in a point.

Muller says he found these eels in the sediment which is formed by vegetables on the sides of vessels in which water has been kept for some time.

The eels of paste have been more distinguished than most other animalcula, as well on account of the various speculations and theories to which it has given rise, as their many curious properties. Four different species of eels may be found in paste; of the first, which has been described very briefly in page 511, we shall now give a more particular description. To be certain of procuring these eels, boil some flower in water, to which you have added a few drops of vinegar, provide an earthen pot which has a hole at the bottom, fill it with earth, and then put the paste in a piece of coarse cloth, and bury it in this earth; the pot is to be exposed to the sun in the summer, or kept in a warm place in the winter; by this means you will very seldom fail of finding in ten or twelve days a large quantity of eels in the paste.

This eel, when at it's full growth, is about one-tenth of an inch long, and rather less than one-hundredth of an inch in diameter: Fig. 6, Plate XI. represents one of these eels magnified about one hundred and twenty times; only compressed so much between two plates, by means of an adjusting screw, as not only to prevent it from moving, but to lengthen and flatten it in a small degree.

degree. At the upper part there are two little moveable pieces, or nipples, *a a*, between which an empty space *b* is formed, that terminates in the mouth; the hinder-part is round, but there projects from it a short fetaceous tail *w*; in the young eels the termination of the tail is not so abrupt as in the present specimen, but it finishes by a gradual diminution. There is probably a vent near *z*, for the passage of the excrements; because when that part has been gently pressed, two or three jets, of a very subtle substance, have been observed to issue from it. If the pressure is increased, a small bladder will be forced out, a further compression bursts the bladder, and the bowels are forced through the opening.

A greater degree of magnifying power is necessary to obtain an exact idea of the viscera of these eels. Fig. 10 represents the alimentary duct (further magnified) from it's origin to the belly. It is shewn here as separated from the animal, which is easily effected; for nature, assisted by very little art, performs the operation. The oesophagus, *b c*, Fig. 6 and 10, at it's origin *a a*, is very small, but soon grows larger, as at *c*, and forms a kind of oblong bag, *c d*; the diameter of this increases till it comes to *d*, where it swells out as at *d e f*; it then grows smaller till it comes to *g*, when it again swells out as *g k l*. There is a narrow neck at *i*, which in it's natural state is seen in the bag *k l*. The part *k l* is the stomach. M. Beeli has shewn, that the alimentary duct of many species of worms is formed of two bags, one of which is inclosed within the other. It is the same with this animalculum; the little vessel *b c*, that we have called the oesophagus, which is the origin of the bag *c d*, enters into the same bag, and preserves it's form within it, till it comes to *m*,

from whence it is prolonged in the form of a black line *m n n*, which passes by the axis of the duct *e e h*, and apparently terminates itself at the beginning of the abdomen *k*. To this tube, near the center of the swelling *g h i*, are fixed two small transparent bodies; that end of these which is connected with the tube is round, the other end is pointed; these small pieces cannot be discerned in every position of the eel.

We must now shew how this duct is to be forced out of the eel. The body, when compressed, generally bursts either at the head or tail, and always at that part which is least pressed; hence when the mass of fluids contained in the body is forced towards the anterior part, they meet with a resistance in passing from the abdomen to the duct already described; the abdomen being forced by the fluids which are made to act against it, bursts at the upper part, and the fluids striking against the neck *g h i*, force it, with all its contents, out of the body, through an opening at the anterior part; on lessening the pressure, the bowel, thus discharged, will float in the water between the two plates of glass.

Not to enter into a detail of those parts which have been supposed by some writers to constitute the heart, &c. of these minute animalcula, it will be sufficient here to describe those in which motion may be discovered, and to leave the rest to future observations on the subject. The parts which may be seen in motion within these minute creatures are, 1. the small tube, or duct, from its origin at *m*, to the two appendages; 2. these appendages themselves; 3. the remainder of the tube, from the appendages to the insertion at the ventricle *k*; 4. in the swelling *g k l*. The rest of this duct, from the beginning by the

oesopha-

oefophagus b c, to the second swelling, has no motion. There is a variety in the motions of the first part of this duct, sometimes it dilates and contracts, at other times it has an oscillatory motion. It is difficult to gain a good view of the appendages, but when the position of the little creature is favorable, they seem to have a two-fold motion, by which the pointed ends approach to, and then separate from each other, and another by which they move up and down. The part g k l moves backwards and forwards alternately, the motion of each of these parts is independent of the rest. These are the principal parts, whose motion is connected with the life of the animal.

The other viscera that are contained in the body of the eel, and which may be observed by the aid of the microscope, are the vessels which contain the food, those which are filled with a transparent substance, and the womb, or ovary. The first form the abdomen and intestines; these are filled with a black substance, which prevents their being properly and clearly distinguished; these vessels, in their passage through the posterior part of the body, form an empty space, in which we may perceive that one side of the animalculum is occupied by the ovary q q q, which runs from j to u x; it is at these two extremities of the ovaries that the eggs begin to be formed, for the largest eggs are always to be found in the middle, and the smallest at the ends, as may be seen at j f and u x.

All the eels which bear eggs have two protuberances, y y, formed on the exterior part, near the center of the ovary; it appears like a transparent semicircular membrane, but is really a kind of hernia, or bag, in which one or two eggs may be some-

times seen; all the larger eels have this appendage, which also bears the marks of having been burst. Now as the younger eels have not this appendage, nor any marks of a rupture, we may reasonably conclude that it is from hence that the little eels issue from the parent.

In the latter part of the year, and during the winter, these eels are oviparous; and the young eels may be seen to proceed from the egg; at other times they are viviparous, six live eels have been seen at one time in the belly of the parent, twenty-two eggs have been counted in the ovary. M. Muller suspected that there was a difference of sex in some of these animalcula, but it was left to M. Roffredi to afford the proof, and it was only from a variety of repeated observations that he could allow himself to be convinced of this truth. He continued his researches upon the same subject on other microscopic eels, and has since been able to distinguish the sexual parts of the vinegar eels.

The next eel we shall describe is the eel of vinegar, Fig. 7, and that because it is oviparous and viviparous; like the preceding it is filiform, but in other respects they differ considerably. It is longer, not near so large, the tail is smaller, and more tapering than that of the paste eel; it moves with much greater ease, and is more lively. We may observe in small, at the tail of this eel, what may be seen at large at the beginning of the viper's tail, a little kind of tongue *a b*, which sometimes adheres to the skin, at other times is separated from it. An alimentary duct may be easily discovered, but no other intestines can be discerned, without deranging altogether the organization of the animalculum.

The

The second species of paste eel is oviparous. It is easily distinguished from the first kind, by being much smaller; it is represented at Fig. 8. The conformation of the alimentary duct and the intestines are in general nearly the same, though an intelligent observer will find out some specific differences. By the flexion of the intestines c c c, a void space is left a little beyond the middle of the body, where the eggs are collected. There is no exterior protuberance near the ovary, as in the preceding one, but a small hole, l, may be discovered, near which are placed two little tubercles f f, though they are very seldom to be observed without compressing the animalcula.

We meet with another eel in paste, which may with reason be called the common eel. It is often to be found in grains placed in the earth, in which the germ is destroyed, in the roots and stems of farinaceous plants, in the tremella of Adanson, and in several species of conserva, as well as in several infusions. This eel, when at it's full growth, is rather longer than the common eel of blighted wheat; one of them is represented at Fig. 11. They are easily distinguished from the eels of blighted wheat, because they have no ranges of globules like it, by the two little protuberances which are near the middle of the body, and by the regular diminution of the tail. It is oviparous.

A very small species, represented at Fig. 9, may also be found in paste; they may be distinguished from the young eels of the larger sort by their vivacity and slenderness.

OF THE EELS IN BLIGHTED WHEAT.*

These animalcula were discovered by Mr. Needham, and described by him in a work entitled *New Microscopical Discoveries*. They are not lodged in those blighted grains which are covered externally with a foot-like dust, (whose inside is often also little more than a black powder) but abundance of ears may be observed in some fields of corn, which have grains that appear blackish, as if scorched; these, when opened, are found to contain a soft white substance, that, when attentively examined, looks like a congeries of threads, or fibres, lying as close as possible to each other in a parallel direction, and much resembling the unripe down of some thistles. This fibrous matter does not discover any signs of life or motion, unless water be applied to it; the fibres then separate, and prove themselves to be living creatures.

These eels are in general of a large size, and may be seen with a common magnifying glass, being about one-thirtieth of an inch in length, and one hundred and fortieth broad. Fig. 5 represents one of them magnified about one hundred and twenty times; they are in general of a bright chestnut colour, the extremity a b is whiter and more transparent than the rest of the body. The end a is rather round, the end b is pointed. A distinguishing mark of these little creatures is a row of transparent globules, which are placed at intervals through the whole length of the body, beginning at b, where the transparency of the fore-part ceases, and going on to the extremity c. They are in diameter rather less than one-third of the body. Another peculiar mark

is

* *Bléd avorti.*

is a small lunular transparent space *c* near the middle of the body. This part is transparent, and is free from the coloured matter of the intestines; there is a neck in the intestines near this space, which confines them to one part of the body.

Great care should be taken by the observer not to burst the skin of the eels in disengaging them from the grain, for they never break or burst of themselves; but if broke, visible intestines, filled with a black matter, rush out of the body, from which little black globules are disengaged, which swim slowly about the water, but without any principle of internal motion; when the observation is made, immediately after the grains proceed from the eel; but if the eels that are broke are left long in the water, the same phænomena will take place, as in other animal and vegetable infusions. It is owing to not properly attending to these circumstances, that we may attribute many of the fanciful positions of M. Needham, which were deduced from ill-conducted experiments, and which, when properly examined, are found to be in a great measure false.

M. Roffredi sowed some of the grains of this wheat, which sprang up; but the ear was either wholly or in a great part spoiled, being filled with these eels. He also found them in other parts of the plant; to disengage them from the plant, it must be soaked in water, and then compressed a little. At first sight these eels seem to resemble the foregoing, but a more accurate inspection shews that they have not the same curious disposition of the internal globules, nor the same transparent place in the middle of the body. The intestinal bag leaves indeed in these an empty space, but it is of an indetermined form. The animalcula from
the

the plant are much more lively than those which are procured from the dried grains.

The principal phenomena of this kind of blighted wheat is probably owing to these animalcula, who prevent the regular circulation of the sap. They increase in their size in a certain proportion to the plant, so that at last they may be observed with great ease by the naked eye, being two-tenths of an inch long, and nearly one-tenth in diameter. Fig. 4 represents one of these magnified nearly in the same proportion as Fig. 5; a a the ovary, which may be traced almost from the lower extremity to the middle of the body, where the body becomes so opaque as to prevent it's being seen any further. The eggs, when arrived at their full growth, are nearly of a cylindric shape, both ends rounded; towards the extremity b there are two little protuberances d d, through which the eggs are most probably extruded; these protuberances are not always visible. The eggs are formed of a fine transparent membrane; it covers the young eel, which is folded curiously therein; these eggs may often be found in the plant.

A most satisfactory view of these eels is obtained by examining them with the solar microscope; it affords one of the most surprising and magnificent spectacles; two generations may be often seen, one which draws near the allotted period of it's existence, and another which only begins to enjoy the blessings of life. Some arrived at their full growth, others quite small, &c. In some we may perceive the young animalcula in motion in the eggs, in others no such motion can be observed; with a variety of
of

of other circumstances too tedious to enumerate, though they afford great pleasure to the spectator.

One of the most remarkable circumstances in these animalcula is the faculty they have of receiving again the powers of life, after having lost them for a considerable time; for instance, when some of these blighted grains, that have been preserved for many years, have been soaked in water for ten or twelve hours, you will find in it living eels of this species; if the water evaporates, or begins to fail, they cease to move, but on a fresh application will be again revived.

It may be proper to notice here, that according to the observations of M. Roffredi, those eels which have done laying of eggs are incapable of being resuscitated upon being moistened; the same seems to be also the case with those that are very young; it is probable they must attain a certain age and degree of strength before they are endowed with this wonderful faculty.

In the month of August, 1743, a small parcel of blighted wheat was sent by Mr. Needham to Martin Folkes, Esq. President of the Royal Society, (with an account of his then new discovery) which parcel the president was pleased to give to Mr. Baker, desiring him to examine it carefully; in order so to do, he cut open some of the grains that were become dry, took out the fibrous matter, and applied water to it on a slip of glass, but could discern no other motion than a separation of the fibres or threads, which separation he imputed wholly to an elasticity in the fibres; and perceiving no token of life, after watching them with due care, and repeating the experiment till he was weary,

an account thereof was written to Mr. Needham, who having, by trials of his own, found out the cause of this bad success, advised him to steep the grains before he attempted to open them; on doing which, he was very soon convinced of his veracity, and entertained with the pleasing sight of this wonderful phenomenon. At different times after this, Mr. Baker made experiments with grains of the same parcel, without being once disappointed. He soaked a couple of grains in water for the space of thirty-six hours, when believing them sufficiently moistened, he cut one open, and applying some of the fibrous substance to the microscope in a drop of water, it separated immediately, and presented multitudes of the *anguillæ*, without the least motion or sign of life; but being taught by experience that they might notwithstanding possibly revive, he left them for about four hours, and then examining them again, found much the greatest number moving their extremities pretty briskly, and in an hour or two after they appeared as lively as these creatures usually are. Mr. Folkes, and some other friends, were witnesses of this experiment. We find an instance here that life may be suspended, and seemingly destroyed; that by an exhalation of the fluids necessary to a living animal, the circulations may cease, all the organs and vessels of the body may be shrunk up, dried, and hardened; and yet, after a long while, life may begin anew to actuate the same body, and all the animal motions and faculties may be restored, merely by replenishing the organs and vessels with a fresh supply of fluid. Here is a proof that the animalcula in the grains of blighted wheat can endure having their bodies quite dried up for the space of four years together, without being thereby deprived of their living power.

It appears plainly from the foregoing experiments, that when the blighted grains of wheat have been kept a long time, and the bodies of these animalcula are consequently become extremely dry, the rigidity of their minute vessels requires to be relaxed very gently, and by exceeding flow degrees; for we find, that on the application of water immediately to the bodies of these animalcula, when taken from the dry grains, they do not so certainly revive as they do if the grains themselves be either buried in earth, or steeped in water for some time before they are taken out: the reason of which most probably is, that too sudden a relaxation bursts their delicate and tender organs, and thereby renders them incapable of being any more employed to perform the actions of life; and indeed, there are always some dead ones amongst the living, whose bodies appear bursten, or lacerated, as well as others that lie extended and never come to life.

Some discretion is needful to adapt the time of continuing the grains in water or earth, to the age and dryness of them; for if they are not opened before they have been too much or too long softened, the animalculum will not only seem dead, but will really be so. Of the two grains he mentions to have been four years old when put to soak, he opened one after it had lain thirty-six hours, and the event was as already related: the other was let lie for above a week, and on opening found all the anguillæ near the husk dead, and seemingly in a decayed condition; but great numbers issued alive from the middle, and moved themselves briskly. Unless the husks are opened to let these creatures out after they have been steeped, they all inevitably perish; and when taken out and preserved in water, if the husks are left with them

they will die in a few days; but otherwise, they will continue alive in water for several months together; and, should the water dry away, may be revived again by giving them a fresh supply.

As the eels in paste are an object which are so often exhibited in the microscope, it will be proper, before we leave this subject, to inform the reader how he may procure the young eels from the parent animalcula, a discovery which was originally made by Mr. Sherwood, but more particularly pursued and described by Mr. Baker. Take up a very small quantity of paste where these eels abound on the point of a pin, or with a sharpened quill; lay it on a slip of glass, and diluting it well with water, many of them will become visible to the naked eye; then with the nib of a pen, cut to a very fine point, and shaved so thin as to be extremely pliable, single out one of the largest eels, and insinuate the point of the pen underneath it; remove it into a very small drop of water, which you must have ready prepared on another slip of glass. When thus confined, it may easily be cut asunder transversely, by the help of a good eye and steady hand, with a lancet or sharp penknife; or if the eye is deficient, a hand-magnifier will enable almost any-body to perform the operation. As soon as the parts are separated, apply your object to the microscope, and if the division has been made about the middle of the animal, several oval bodies, of different sizes, will be seen to issue forth. These are young *anguillæ*, of different degrees of maturity, each whereof is coiled up, and included in its proper membrane, which is of so exquisite a fineness, as to be scarce discernible by the greatest magnifier while it incloses the embryo animal. The largest and most forward break immediately through this delicate integument, unfold themselves, and wriggle about in the water, nimbly;

nimbly; others get out, uncoil, and move about more slowly; and the least mature continue entirely without motion. The uterus, or vessel that contains all these oval bodies, is composed of many annula, or ringlets, not unlike the aspera arteria of land animals, and it seems to be considerably elastic; for as soon as the operation is performed, the oval bodies are thrust out with some degree of violence, by the springing back or action of this bowel. An hundred or upwards of the young ones have been seen to issue from one single eel, whereby the prodigious increase of them may be accounted for, as probably several such numerous generations are produced in a short time. Hereby we also learn that these creatures are not only like eels in shape, but are likewise viviparous, as eels are generally supposed to be.

There is scarce a more entertaining experiment, in which there is but little risk of being disappointed; for they seem, like earth-worms, to be all prolific, and unless by accident you cut one that has brought forth all its young before, or make your trials when the paste has been kept a very long time, (in which case they have been found sometimes unfruitful) you may be sure of success.

Anguillula Marina.

This, when pressed between two plates of glass, appears to be little more than a crystalline skin, with a kind of clay-coloured intestines. The fore-part of the body is truncated, the lower part drawn out to a fine point, the rest of the body is of an equal size throughout. The younger ones are filled with pellucid molecular intestines.

72. *Vibrio Linter.*

Vibrio ventricoso-ovatus, collo brevissimo. Ventricose oval vibrio, with a short neck.

This is one of the larger animalcula, of an egg shape, pellucid, inflated, somewhat depressed at top; the apex is prolonged into a moveable crystalline neck, the belly is replete with pellucid molecules. It is not very common, but is to be found among the lemnæ.

73. *Vibrio Utriculus.*

Vibrio teres, antice angustatus truncatus, postice ventricosus. Round vibrio, the fore-part narrow and truncated, the lower ventricose.

It does not ill resemble a bottle in shape; the belly is replete with molecular intestines, the neck bright and clear, the top truncated; in some a pellucid point is visible at the bottom of the belly. It is in an unceasing, vehement, and vacillatory motion, the neck moving from one side to the other as fast as possible.

74. *Vibrio Fasciola.*

Vibrio antice attenuatus, medio latiusculus, postice acutus. Vibrio with a small fore-part, the middle a little bigger, the hind-part acute.

This

This is a pellucid animalculum, in the middle are the intestines in the form of points; an alimentary pipe, which lessens gradually in size, is also perceptible.

The motion of it is quick, darting itself up and down the water with great velocity. It is found in water just loosened from the frost, and seldom elsewhere.

75. *Vibrio Colymbus.*

Vibrio crassus, postice acuminatus, collo subfalcato. Thick vibrio, sharpened at the end, the neck a little bent.

It is larger than most of the vibrios, and not unlike a bird in shape. The neck is round, shorter than the trunk, of an equal size throughout, and of a bright appearance, the apex obtuse. The trunk is thick, somewhat triangular, full of yellow molecules; the fore-part broad, the hinder-part acute, the motion slow.

76. *Vibrio Strictus.*

Vibrio elongatus linearis, anticem versus attenuatus, apice obtuso. Vibrio lengthened out almost to a line, small towards the fore-part, the apex obtuse.

The body linear, being a membranaceous bright thread, without any flexure; the hind-part thicker, round, and filled with molecules, excepting just the end, where there is a small pellucid

empty space. The apex is obtuse, and rather globose; it has a power of contracting and drawing in the filiform part.

77. *Vibrio Anas.*

Vibrio oblongus, utroque fine attenuatus, collo cauda longiore. Oblong vibrio, both ends attenuated, the neck longer than the tail.

The trunk round, oblong, opaque, and crammed with molecules. Both the fore and the hind-part is prolonged into a pellucid talcy membrane, which the animalculum has a power of retracting at pleasure. The neck is longer than the tail, and the tail is more acute than the neck. It is most generally found in salt water; a species of them have been found in river water, with a longer neck.

78. *Vibrio Cygnus.*

Vibrio ventricosus, collo adunco. Corpulent vibrio, with a crooked neck.

This animalculum is little more than a most pellucid line, crooked at top, prominent in the middle, and sharp at the end; the fore-part, or neck, is equal in length to the rest of the body, and three times longer than the hind-part, or tail, the intermediate part swelling out, and is full of darkish molecules and pellucid intestines. It is very small, and the most slothful of all those which move and advance their necks.

79. *Vibrio*

79. *Vibrio Anser*. Fig. 27 and 29, Plate XXV.

Vibrio ellipticus, collo longo, tuberculo dorsali. Elliptical vibrio, with a long neck, and a little lump on the back.

It is between the *vibrio proteus* and *vibrio falx*, and is distinguished by the lump b, Fig. 29, on the back, placed behind the neck; from this an even long neck (a) proceeds.

The trunk (d) is elliptic, round, and without any lateral inequality, full of molecules, the hind-part sharp and bright, the fore-part produced into a bending neck, that is longer than the body; the apex even and whole, blue canals passing between the marginal edges, occupying the whole length of the neck; in one of them a vehement descent of water to the beginning of the trunk is perceivable.

The motion of the body is slow, that of the neck is more lively and flexuous, sometimes spiral. It is found in water where there is duck-weed.

80. *Vibrio Olor*. Fig. 28, Plate XXV.

Vibrio ellipticus, collo longissimo, apice nodoso. Elliptical, with a very long neck, and a knob on the apex.

An animalculum which is continually moving it's lively neck. The form of the body is elliptical and ventricose, the hind-part somewhat sharp. It is membranaceous, dilatable, winding variously; the hind-part is sometimes replete with darkish molecules.

cules. The neck (d) is three or four times longer than the body, of an equal size throughout, except a small degree of thickness at the apex (f) very pellucid. The neck is very lively in it's motions, the body flow.

Is found in water that is kept for a long time, and which is full of a vegetable greenness.

81. *Vibrio Falx.*

Vibrio gibbosus, postice obtusus, collo falcato. A gibbous vibrio, the hind-part obtuse, the neck crooked.

The body is pellucid, elliptical, the fore-part lessening into a little round bright neck, nearly of the same length as the trunk, the hind-part obtuse. The trunk itself is rather rounding or tending to the gibbous, and filled with very small molecules; there are also two bright globules, one within the hind extremity, the other in the middle of the body. The immobility of the neck gives it motions much the resemblance of a scythe.

82. *Vibrio Intermedius.*

Vibrio membranaceus, antice attenuatus, postice subacutus. Membranaceous vibrio, the fore-part small, the hinder-part somewhat acute.

It seems to be an intermediate species between the vibrio falx and the fasciola; it is a thin membrane, constantly folded. The whole of it is of a crystalline tawny appearance, the middle replete with

with grey particles, of different sizes; it has all round a distinct bright margin, the apex of the neck is truncated, the tail obtuse.

VI. CYCLIDIUM.

Vermis inconspicuus, simplicissimus, pellucidus, complanatus, orbicularis vel ovatus. A simple, invifible, pellucid, flat, orbicular, or oval worm.

83. Cyclidium Bulla.

Cyclidium orbiculare hyalinum. Orbicular bright cyclidium.

A very pellucid white animalculum, or orbicular skin, the edges a little darker than the rest. By the assistance of the compound microscope, some globular crystalline-like intestines are just perceptible. It moves slowly and semicircularly. Is found occasionally in an infusion of hay.

84. Cyclidium Millium.

Cyclidium ellipticum crystallinum. Elliptic and crystalline cyclidium.

It is very pellucid, and more splendid than chrystal, membranaceous, elliptical; a line is perceived through the whole length of it, a point in the fore-part, the hinder-part getting darker. It's motion swift, fluttering, and interrupted; it is probable that both extremities are ciliated.

85. *Cyclidium Fluitans*.

Cyclidium ovale crystallinum. Oval crystalline *cyclidium*.

This is one of the smallest animalcula. The body of an oval, or rather a suborbicular shape, depressed, crystalline; two small blue spaces may be discovered, by the assistance of the microscope, at the sides of this little creature.

86. *Cyclidium Glaucoma*.

Cyclidium ovatum, interaneis ægre conspicuis. Oval *cyclidium*, the intestines perceived with difficulty.

A pellucid oval body, both ends plain, or an oval membrane, with a distinct well-defined edge; the intestines, when it is empty, are so transparent, that they are with difficulty discerned; being full, they are manifested by their green colour; dark globules are discoverable in the middle.

In plenty of water it moves swiftly in a circular and diagonal direction; whenever it moves slowly it seems to be taking in water, the intestines are then also in a violent commotion. Two of the smaller ones may often be perceived cohering to each other, and drawing one another by turns; nor are they separated by death, for they remain united even when the water is evaporated. The unskilful in observation must be careful lest they mistake the shade in a single one for a junction of two, or the junction of two for a copulation, for they generate by division.

87. *Cyclidium Nigricans.*

Cyclidium oblongiusculum, margine nigricans. Oblong cyclidium, with a black margin.

It is very small, pellucid, flat, and with a black margin. With a small magnifier it may be mistaken for an enchelis.

88. *Cyclidium Rostratum.*

Cyclidium ovale, antice mucronatum. An oval cyclidium, the fore-part pointed.

This is an oval, smooth, and very pellucid animalculum, the fore-part produced into an obtuse point; with this it feels and examines bodies. It is probably ciliated, though the hairs have not been discovered.

The intestines are filled with a blue liquor; forming in a tube, which, from the aperture to the middle of the body, is divided into two legs, or branches; beyond the middle there are two little transverse blue lines. The colour sometimes vanishes, and then only vesicular intestines are discerned.

89. *Cyclidium Nucleus.*

Cyclidium ovale, postice acuminatum. An oval cyclidium, the hind-part pointed.

The

The body is pellucid, depressed, the fore-part obtusely convex, the hind-part acute, the intestines vesicular, the fore and hind-part on each side dark. It resembles a grape-feed.

90. *Cyclidium Hyalinum*.

Cyclidium ovatum, postice acutum. Oval cyclidium, the hind-part acute.

This cyclidium is oval, flat, and bright, without any visible intestines, the hinder part somewhat smaller than the fore-part; it has a tremulous kind of motion.

91. *Cyclidium Pediculus*.

Cyclidium ovale convexum, subtus planum. An oval convex cyclidium, the bottom even.

Trembley Polyp. 1. p. 282.

This is a gelatinous white animalculum, the bottom over the back gibbous, the extremities depressed and truncated, sometimes one end seems cloven into two points, perhaps this is the aperture of the mouth.

It runs upon the hydra pallida as if it had feet, going back again every moment. It is scarce ever seen but on the arms and the body of the hydra.

92. *Cycli-*

92. *Cyclidium Dubium*.

Cyclidium ovale, supra convexum, subtus cavum. Oval *cyclidium*, the upper part convex, the under part concave.

This is one of the larger species; the body is of an oval shape, one side is convex, the other is concave, the margin is pellucid, the inner part contains a great number of black molecules.

VII. *PARAMÆCIUM*.

Vermis inconspicuus, simplex, pellucidus, membranaceus, oblongus. An invifible, fimple, pellucid, membranaceous, flat worm.

93. *Paramæcium Aurelia*.

Paramæcium compressum, versus anticam plicatum, postice acutum. *Paramæcium* compressed, oblong, folded towards the fore-part, the hinder-part acute.

Volvox Terebella. Ellis.

This is rather a large animalculum, membranaceous, pellucid, four times longer than it is broad, the fore-part obtuse, transparent, without intestines, the hind-part replete with molecules of various sizes; the fold which goes from the middle to the apex is a striking characteristic of the species, forming a kind of triangular

gular aperture, and giving it somewhat the appearance of a gimlet. Its motion is rectilinear, vacillatory, and generally vehement.

They may often be seen cohering lengthways; the lateral edges of both bodies appear bright. They may also sometimes be seen lying on one another by turns, and sometimes cohering by the middle. They live many months in the same water if it is not renewed. They are to be found in June, in ditches where there is plenty of duck-weed.

94. *Paramæcium Chrysalis*. Fig. 26, Plate XXV.

Paramæcium cylindraceum, versus anticamplicatum, postice obtusum. Cylindrical paramæcium, folded towards the fore-part, the hinder-part obtuse.

It differs but very little from the preceding, only the ends (a b) are more obtuse; the margin is filled with black globules, and it is an inhabitant of salt water.

95. *Paramæcium Versutum*.

Paramæcium cylindraceum, postice incrassatum, utraque extremitate obtusum. Cylindrical paramæcium, the lower part thick, and both ends very obtuse.

An oblong body, green, gelatinous, filled with molecules, the lower part thick, the fore-part smaller, both ends obtuse, and may be seen to propagate by division. Is found in ditches.

96. Para-

96. *Paramæcium Oviferum*. Fig. 25, Plate XXV.

Paramæcium depresso, intus bullis ovalibus. *Paramæcium depresso*, with large oval molecules within side.

A membranaceous, oval, oblong animalculum, grey, pellucid, having many oval very pellucid corpuscles (a) dispersed about the body, and many black grains towards b.

97. *Paramæcium Marginatum*. Fig. 24, Plate XXV.

Paramæcium depresso, griseum, margine duplici. *Paramæcium depresso*, grey, with a double margin.

This is one of the largest of this class, flat, elliptical, every part filled with molecules, except the lower end (b), where there is a pellucid vesicle; this animalculum is surrounded by a broad double margin; when expiring, a bright spiral intestine may be seen. (a), Fig. 24, the apex, (b) the vesicle, (c) the spiral intestine.

VIII. KOLPODA.

Vermis inconspicuus, simplicissimus, pellucidus, complanatus, sinuatus. An invisible, very simple, pellucid, flat, crooked worm.

98. *Kolpoda Lamella.*

Kolpoda elongata membranacea, antice curvata.

This animalculum is a pellucid membrane, long and narrow, the hind-part obtuse, narrower, and curved towards the top; no intestines discoverable, only a ridge, or fold, going through the middle. It's motion is vacillatory and singular, moving to and fro on it's edge, not on the flat side, as is usual with most microscopic animals. It is found in water, but is very seldom to be met with.

99. *Kolpoda Gallinula.*

Kolpoda oblonga, dorso antico membranaceo hyalino. Oblong kolpoda, the back towards the fore-part bright and membranaceous.

The apex rather bent, the belly oval, convex and striated. It is found in foetid salt water.

100. *Kolpoda Rostrum.*

Kolpoda oblonga, antice uncinata. Oblong, the fore-part hooded.

The fore-part is bent into a kind of hook, the hind-part is obtuse, and every-where filled with black molecules. One of the edges, from the fore-part to the middle, is often so blunted and dilated.

dilated that the rest of the body appears quite smooth, and that part thick and triangular. Its motion is slow and horizontal. It is to be found in water where there is lemna, but not often.

101. Kolpoda Ochrea.

Kolpoda elongata, membranacea, apice attenuato, basi in angulum rectum producta. Kolpoda long, membranaceous, the apex attenuated, the base bent in a right angle to the body.

A large animalculum, long, and of a singular figure, depressed, membranaceous, flexible; one edge nearly straight, the other somewhat bent, filled with obscure molecules, and a few little bladders dispersed here and there; the apex bright and small, the base projecting like the human foot from the leg.

102. Kolpoda Mucronata.

Kolpoda membranacea dilatata, antice angustata, altero margine incisa. Membranaceous dilated kolpoda, the fore-part smaller than the hind-part, with a small incision at one side.

This animalculum is a dilated bright membrane, the apex an obtuse point, a broad marked border running entirely round it; within the margin it is filled with grey molecules, a fleshy disc on one side, which terminates in a splendid little point on the other side the disc. It has a truncated appearance.

103. *Kolpoda Triquetra*.

Kolpoda obovata depresso, altero margine retuso. *Kolpoda* nearly of an egg-shape, one edge turned back.

This animalculum seems to consist of two membranæ, the upper side flattened, the lower convex; the apex is bent so as to form a kind of shoulder. It was found in salt water.

104. *Kolpoda Striata*.

Kolpoda oblonga, subarcuata depresso, candida antice acuminata, postice rotundata. Oblong, somewhat of a pear-shape, white, the fore-part pointed; the hind-part round.

It is very pellucid and white, the upper part rather bent, and terminating in a point, the lower part obtusely round; at the apex, or mouth, there is a little black pellucid vesicle; when a very great power is used, the body appears covered with long streaks; the lower extremity is furnished, like many other animalcula, with very small globules. Is to be found in salt water.

105. *Kolpoda Nucleus*.

Kolpoda ovata, vertice acuto. Egg-shaped kolpoda, with an acute vertex.

It is of an oval shape, the vertex pointed, of a brilliant transparency, which renders the viscera visible; they consist of a heap of round diaphanous vesicles.

105. Kol-

106. *Kolpoda Meleagris*.

Kolpoda mutabilis antice uncinata, postice complicata. Changeable, with the fore-part like a hook, the hind-part folded up. Fig. 22, Plate XXV.

A most singular animalculum; of the larger species; it has a dilated membrane, with the finest folds, which it varies and bends in a moment; the fore-part of the body to the middle is clear and bright, the hind-part variously folded in transverse elevated plaits, and full of molecules; the apex turned into a hook, the margin sinuous, and beneath the apex denticulated with three or four teeth; or in some which are more beautifully wrought, the edge is obtusely notched, and set with still smaller notches; in the hind-part there are twelve or more equal pellucid globules. It moves sometimes in a strait, sometimes in a crooked line. Fig. 22, Plate XXV. a the hooked apex, b the denticulated margin, c the series of globules, d the folded part at bottom.

107. *Kolpoda Affimilis*.

Kolpoda depressa, non plicatilis apice uncinato, margine antico ad medium, usque crenulato postice, dilatato acutiusculo. *Kolpoda* depressed, the apex turned in the form of a small hook, the margin of the fore-part notched from the top to the middle, the lower part swells out, then diminishes again into a short point. It is never folded like the foregoing; it has an elliptic mass in the middle. It was found on the sea-coast.

108. *Kolpoda Cucullus*. Fig. 23, Plate XXV.

Kolpoda ovata ventricosa, infra apicem incisa. Egg-shaped ventricose, with an incision in the fore-part.

It is very pellucid, with a well-defined margin, filled with little bright vesicles, differing in number and size. The figure of the most part is oval, the top bent into a kind of an obtuse beak, seldom an acute one, but sometimes oblong. It's intestines are formed of from eight to twenty-four bright little vesicles, these are not conspicuous in the young ones; some have supposed that these were animalcula that had been swallowed by the kolpoda, but Mr. Muller thinks they are the offspring of the kolpoda. In some only one crystalline vesicle occupies the middle of the body. When the water is almost exhaled, and death nigh, it moves more slowly than usual, and protrudes it's offspring with violence.

It moves in general with great vivacity, and in all directions. a the cap or hood, b the incision. It is found in infusions of vegetables, and in foetid hay. In some few a transparent membranaceous substance may be perceived projecting beyond the beak, and resembling an exuvia; the same may be observed in the *enchelis vibrio*, and it is probable that a decortation or casting of the skin has place in these animalcula, as well as in insects.

109. *Kolpoda Cucullulus*.

Kolpoda oblonga, infra apicem oblique incisa. *Kolpoda oblonga*, with an oblique incision a little below the apex.

A very pellucid crystalline animalculum; it is furnished with several pellucid globules; there is a bending a little beneath the top, which in some positions is very distinctly seen, in others not. It was observed in an infusion of the *fonchi arvenfis*.

110. *Kolpoda Cucullio*.

Kolpoda ovalis depressa, infra apicem tantillum sinuata. Flat oval *kolpoda*, with a small degree of bending beneath the apex.

This is an oval, or rather an elliptical *kolpoda*, flat on the upper side, convex on the under side, membranaceous and bright, the fore-part clear; from the middle to the hinder-part it is filled with silver-like globules. It often stretches out the fore-part, and folds it in different positions.

111. *Kolpoda Ren*.

Kolpoda crassa medio sinuata. This *kolpoda* is thick, and curved in the middle.

The body is yellow, thick, and rather opaque, even where round, curved a little in the middle, so as to have the appearance of a kidney; the whole body is filled with molecules. Its motion.

tion is quick, vacillatory, and interrupted. If the water in which it swims fail, it assumes an oval form, is compressed, and at last bursts. It is found in an infusion of hay, generally about thirteen hours after the infusion is made.

112. *Kolpoda Pirum*. Fig. 20 and 21, Plate XXV.

Kolpoda convexa, ovalis, apice in rostrum producta. Convex kolpoda, oval, the apex formed into a kind of beak.

The body is uniform and transparent, without any sensible inequality, the neck rather long, and a little bent; it is of a pale colour, and furnished with obscure little globules. Fig. 20 represents this animalculum, 21 the same dividing to form another, a the fore-part, b the hind-part, c where it is dividing.

113. *Kolpoda Cuneus*.

Kolpoda clavata, teres, apice dentata. Clavated kolpoda, round, the apex dentated.

This is a large animalculum, the body white, gelatinous, without any distinct viscera. On the fore-part at one side there is a pellucid, bright, striated pustule; the apex is distinguished by three or four teeth, the hinder-part is smaller than the fore-part, with an obtuse termination, which it can bend in a spiral form.

IX. GONIUM.

Vermis inconspicuus, simplicissimus, complanatus, angulatus.
An invisible, simple, smooth, angular worm.

114. Gonium Pectorale. Fig. 17, Plate XXV.

Gonium quadrangulare, pellucidum moleculis sedecim sphaericis. This gonium is quadrangular, pellucid, with sixteen spherical molecules.

These sixteen little oval bodies are nearly equal in size, of a greenish colour, pellucid, and set in a quadrangular membrane, like the jewels in the breast-plate of the high-priest, reflecting light on both sides. It's animality is evinced by it's spontaneous motion, advancing alternately towards the right and left; these little bodies seem oval when in motion, round when at rest; the four interior ones are a little larger than the rest. Found in pure water.

115. Gonium Pulvinatum.

Gonium quadrangulare; opacum, pulvillis quatuor. Quadrangular, opaque, with four little pillows.

This appears under the microscope as a little quadrangular membrane, plain on both sides; with a deeper lens it looks like a bolster, formed of three or four cylindric pillows, flattened or sunk here and there. Thus it appeared to M. Muller on the first

examination; some days after, all the fides were plain, without any convexity, and divided into little square spaces by lines crossing each other. Found upon dunghills.

116. *Gonium Corrugatum.*

Gonium quadrangulare, albidum, medio correptum. Quadrangular gonium, white, sunk a little in the middle.

It is somewhat of a square shape, very minute, without any visible viscera, a little depressed in the middle. It is found in various infusions; in some positions it appears streaked.

117. *Gonium Rectangulum.*

Gonium rectangulum, dorso arcuato. This gonium is rectangular, the hind-part arched.

It differs from the preceding one but little, the angle at the base a right one, the larger vesicle is transparent, the rest green.

118. *Gonium Truncatum.*

Gonium obtusangulum, postice arcuatum. Gonium with obtuse corners, the hind-part arched.

Much larger than the foregoing; the fore-part is a straight line, the fides forming therewith obtuse angles, the ends of these fides are united by a curved line; the internal molecules are of a dark green,

green, there are two little bright vesicles in the middle, it's motion is languid. It is but rarely met with, and then mostly in pure water.

X. BURSARIA.

Vermis simplicissimus, membranaceus, cavus. A very simple, hollow, membranaceous worm.

119. Bursaria Truncatella.

Bursaria ventricosa, apice truncata. Ventricose bursaria, the top truncated.

An animalculum that is visible to the naked eye, white and oval, truncated at the top, where there is a large aperture, the opening that forms the aperture descending towards the base; at the bottom of most of them there are three or five yellow eggs.

It moves itself at pleasure from right to left, and from left to right, ascending to the superficies of the water in a right line; sometimes it rolls about while descending.

120. Bursaria Bullina.

Bursaria cymbæformis, antice labrata. Boat-shaped bursaria, the fore-part formed into a lip.

A pellucid crytalline animalculum, furnished with smaller and larger splendid globules swimming about within it, the under-side convex, the upper-side hollow, the fore-part forming a kind of lip.

121. *Burfaria Hirundinella*. Fig. 19, Plate XXV.

Burfaria utrinque laciniata, extremitatibus productis.

Burfaria with two little projecting wings, one on each side, the fore and hind-part produced so as to give them some resemblance to the head and tail of a bird. It is invisible to the naked eye, but appears to be a pellucid hollow membrane under the microscope. They have no visible intestines; it moves somewhat like a swallow; a the head, b the tail, c one of the wings.

122. *Burfaria Duplella*. Fig. 18, Plate XXV.

Burfaria elliptica, marginibus inflexis. Elliptic burfaria, with the edge bent in and out.

A crytalline membrane folded up, no visible intestines, if we except a little congeries of points under one of the folds. Was found among duck-weed.

123. *Burfaria Globina*.

Burfaria sphaerica, medio pellucentissima. Spherical burfaria, very pellucid in the middle.

A sub-

A subspheric hollow animalculum, the lower end furnished with black molecules of various sizes, the fore-part with obscure points, the rest entirely empty, and the middle very pellucid; it moves slowly from right to left.

XI. CERCARIA.

Vermis inconspicuus, pellucidus, caudatus. An invisible pellucid worm with a tail.

124. *Cercaria Gyrinus.*

Cercaria rotundata, cauda acuminata. This cercaria is round, and has a sharp tail.

The body is white, gelatinous; without any traces of intestines; the fore-part somewhat globular, the hind-part round, long, and pointed; sometimes it appears a little compressed on each side. The tail is in a continual vibration while it is swimming, like that of the tadpoles. It seems very similar to the spermatic animalcula.

125. *Cercaria Gibba.*

Cercaria subovata convexa, antice subacuta, cauda tereti. Somewhat of an oval shape, convex, the fore-part rather acute, the tail round.

It

It is a small animalculum, gelatinous, white, opaque, without any visible intestines, the upper part convex or gibbous; many of them were found in an infusion of hay, also in other infusions.

126. *Cercaria Inquieta*. Fig. 31 and 32, Plate XXV.

Cercaria mutabilis convexa, cauda lævi. Changeable convex cercaria, with a smooth tail.

This animalculum so often changes the form of it's body, that it is not easy to describe it; it is sometimes spherical, sometimes like a long cylinder, at others of an oval figure, white, gelatinous, the tail is filiform and flexible, the upper part vibrating vehemently, no visible viscera, a pellucid globule may be observed at the base, and two very small black points placed near the top at d, Fig. 32; whether they are eyes to the animalculum is not known. Was found in salt water. a, Fig. 31, the body, b the tail.

127. *Cercaria Lemna*, Fig. 33, 34, and 35.

Cercaria mutabilis, subdepressa, cauda annulata. Mutable cercaria, somewhat flattened, with an annulated tail.

This animalculum puts on such various forms, that at first sight it appears like the proteus of Baker, though it is altogether different.

The body is capable of being contracted or extended, of the shape of an oblong pear, or triangular, kidney-shaped. The tail short,

short, thick, and annulated; sometimes long, bending; cylindric, and without rings. It vibrates, when it is stretched out, with so much velocity, that it appears as it were double. The intestines not very distinct, near the apex a small pellucid globule is perceivable, that Muller takes to be it's mouth; two black points which are near it, but with difficulty discovered, he supposes to be the eyes. It draws the tail sometimes into the body. Fig. 33, a, the body rather spherical; b the tail; Fig. 34, c, the triangular body; Fig. 35, the body extended; e e the eyes, ff the bowels, g a large vesicle, b a smaller one.

It walks slowly after taking three or four steps; it extends the tail, erecting it perpendicularly, shaking and bending it; in this state it resembles much the leaf of the lemna.

128. *Cercaria Turbo.* Fig. 30, Plate XXV.

Cercaria globulosa, medio coarctata, cauda uniseti. Globular cercaria, the middle contracted, with a tail like a bristle.

Partly of an oval, and partly of a spherical shape, pellucid, and of a talc appearance. It seems to be composed of two globular bodies, the lower one being the smallest; this figure is occasioned by the contraction at the middle. There are two black points, like eyes, at the upper part of the animalculum, even with a transverse line which crosses the top of this little creature; several large globules may be discerned, the tail is sometimes quite strait, sometimes turned back on the body. It is to be met with among the duck-weed.

129. *Cercaria Poduria*. Fig. 37 and 38, Plate XXV.

Cercaria cylindracea, postice acuminata subfissa. Cylindric cercaria, the hind-part sharp, and somewhat cloven.

It resembles the young ones of the podura which live among the lemna, is pellucid, and seems to consist of a head, a trunk, and a tail; the fore-part resembles the head of a herring, the trunk is cylindric, and replete with black spiral intestines; appears more or less ventricose, at the will of the animal. Nothing to be discovered in the hinder-part. The tail, in most situations, appears divided into two bristles. When the animal moves, there is a continual motion among the intestines, which, from the various shades they occasion, make the body appear very rough; some lateral hairs (cilia) are sometimes perceived. It moves from one place to another, turning round at the same time as upon an axis. It is to be found in November and December, in marshy places that are covered with lemna. Fig. 36, a the head, b the trunk, c the tail, d with one point, it is seen at e, Fig. 37, with two points; f the hairs on the side.

130. *Cercaria Viridis*.

Cercaria cylindracea mutabilis, postice acuminata fissa. Cylindrical cercaria, mutable, the lower end sharp, and divided into two parts.

This animalculum, when in it's longest state, is not unlike the preceding; but from the changes to which the body is subject, as well

well as the colour, it differs considerably from it. It sometimes contracts the head and tail, so as to form a spherical figure; at others the sides project outwards. Is found in the spring, in ditches of standing water.

131. *Cercaria Setifera*.

Cercaria cylindracea, antice angustior, postice acuminata. Cylindric cercaria, the fore-part smallest, the hind-part pointed.

This is a small cercaria, the body rather opaque, round, the upper part bright, and smaller than the rest; the trunk is more opaque, the tail sharp, near it is a little row of short hairs. It has a slow rotatory motion, and is seldom to be met with, and when found it is in salt water.

132. *Cercaria Hirta*.

Cercaria cylindrica, antice subtruncata, postice obtusa, bimuscronata. Cylindrical cercaria, the fore-part somewhat truncated, the lower part obtuse, finishing with two small points.

A cylindrical opaque animalculum, with two small points at the lower end, moveable, yet rigid, and placed at some distance from each other; when in motion, the body seems as if it was surrounded with rows of small hairs, separated a little from each other. It was observed in salt water.

133. *Cercaria Crumena.*

Cercaria cylindraceo-ventricosa, antice oblique truncata, cauda lineari bicuspidata. Cylindrical ventricose cercaria, the fore-part obliquely truncated, the tail linear, terminating with two diverging points.

The body is ventricose and cylindrical, muscular and thick, the lower part small; the upper part terminates in a small, straight neck, like the neck of a pitcher; the body appears wrinkled, the tail terminated as in the definition.

134. *Cercaria Catellus.*

Cercaria tripartita, cauda bifecta. Three-parted cercaria, the tail divided into two parts.

This animalculum is more complex in its form than many others; it has a moveable head, which is affixed to the body only by a point; an abdomen, which is not so wide, but twice as long as the head, replete with intestines, and a tail which is shorter than the head, narrower than the belly, and terminating in two bristles; these it can unite and separate at pleasure. It moves with vivacity, though without going far from its first place.

135. *Cercaria Catelina.*

Cercaria tripartita, cauda bicuspidata. Cercaria distinguished into three parts, with a short forked tail.

It differs from the preceding in several respects, being larger, the body thicker, more cylindrical, and the lower part truncated, with two short diverging points projecting from the middle. Was found in a ditch where there was plenty of duck-weed.

136. *Cercaria Lupus*. Fig. 39, Plate XXV.

Cercaria cylindrica, elongata, torosa cauda spinis duabus. Cylindric cercaria, long, the tail furnished with two spines.

This animalculum is larger than most of the cercarias, and has some particulars in which it resembles the vorticella. It is full of muscles, capable of being contracted or extended; cylindric, composed of a head, a trunk, and a tail; the head is larger than the body, the apex turned downwards into a little hook; the tail is like the body, but narrower, terminating in two very bright spines, that it extends differently. It sometimes contracts itself into one half it's size; then again it extends itself to it's usual form. Was found in water among duck-weed. a the head, b the-trunk, c the tail, dd the spine thereof.

137. *Cercaria Vermicularis*. Fig. 40.

Cercaria cylindrica annulata, proboscide exfertili, cauda spina duplici. Cylindrical, annulated, with a projecting proboscis, two small spines for the tail.

It is a long, cylindrical, fleshy, mutable animalculum, divided into eight or nine rings, or folding plaits, the apex either obtuse or notched into two points, the hind-part rather acute, and ter-

3 X 2

minating

minating in two pellucid thorns; sometimes a swelling is perceived between these. It often projects from the incision at the apex, a kind of cloven proboscis. Is found in water where there is duck-weed. d d the points of the fore-part, e the proboscis.

138. *Cercaria Forcipata*.

Cercaria cylindrica, rugosa, proboscide forcipata exferti, cauda bicuspidata.

Cercaria cylindrical, wrinkled, with a forked proboscis, that it can thrust out, or pull in. It is found in marshy situations.

139. *Cercaria Pleuronectes*. Fig. 38, Plate XXV.

Cercaria orbicularis, cauda unifeta. Orbicular the tail, consisting of one bristle.

It is membranaceous, rather round, and white. In the fore-part are two blackish points. The hind-part is furnished with a slender sharp tail. In the middle are orbicular intestines of different sizes; the larger of them are bright. Its motion is vacillatory; in swimming, one edge of the lateral membrane is upwards; the other, folded down. Found in water that has been kept several months.

140. *Cercaria Tripos*. Fig. 38, Plate XXV.

Cercaria subtriangularis, brachiis deflexis, cauda recta. *Cercaria* somewhat of a triangular form, two bent arms, and a straight tail.

The body flat, pellucid, triangular, each angle of the base of the triangle, or fore-part thereof, being bent down into two linear ears, or arms; the apex of the triangle is prolonged into a tail. It was found in salt water; b the tail, a the bent arms.

141. *Cercaria Cyclidium*.

Cercaria ovalis, postice submarginata, cauda extensibili. This is oval, the hind-part somewhat notched, with a tail, that it thrusts out at pleasure.

Its body is oval, smooth, membranaceous, pellucid, with a black margin. The tail is not fixed to the edge, but concealed under it, and coming out from it at every motion, and yet so as to project but little from the edge. There is a kind of border to the hinder-part. Its intestines are very pellucid vesicles. Is frequently found in pure water.

142. *Cercaria Tenax*.

Cercaria membranacea, antice crassiuscula, truncata, cauda triplo brevior. Membranaceous, the fore-part rather thick, truncated, the tail three times shorter.

It is an oval, pellucid membrane, something larger than the mona lens. The fore-edge thick and truncated, the hinder-part acute, or terminating in a short tail. It whirls about in various directions with great velocity.

143. *Cercaria Discus.*

Cercaria orbicularis, cauda curvata. A small orbicular cercaria, with a bent tail.

144. *Cercaria Orbis.*

Cercaria orbicularis; feta caudali duplici longissima. Orbicular cercaria, with a tail, consisting of two very long bristles.

145. *Cercaria Luna.*

Cercaria orbicularis, cauda lineari duplici brevi. Orbicular cercaria, with two short spines for a tail; the fore-part hollowed, so as to form a kind of crescent.

XII. LEUCOPHRA.

Vermis inconspicuus, pellucidus, undique ciliatus. An invisible worm, pellucid and every where ciliated.

146. *Leucophra Conflictor.*

Leucophra sphaerica, subopaca; interaneis mobilibus. Spherical-opake leucophra, with moveable intestines.

This animalculum, or rather a heap of animalcula, is perfectly spherical, and larger than most species of the vorticella; it is semi-transparent, of a yellow colour, the edges of a dark colour. It is filled with a number of the most minute molecules, it rolls at intervals from right to left, but seldom removes from the spot where it is first found.

The innumerable molecules circumscribed within this sphere are in continual motion, and, as it were, in vehement conflict, without any order. From the great concurrence of combatants on one side, or the other, the sphere is turned either to the right or left, the molecules going in the same direction; it is then tranquil for a short time, but soon the conflict becomes more violent, and the sphere is moved towards the other side, and continues to move in a spiral line. When the water begins to fail, they assume an oblong, oval, or a cylindric figure; the hind-part of some is compressed into a triangular shape, and the transparent part escaping as it were from the intestines, which continue to move with the same violence till the water fails, when the molecules are spread into an uninformed mass. But this also soon vanishes, when they shoot into the form of the crystals of sal ammoniac, as described by Baker, p. 3, No. 3.

147. *Leucophra Mamilla.*

Leucophra sphaerica, opaca, papilla exferti. Sphaerical opake leucophra, with a small papillary projection.

It is of a dark colour, and filled with globular molecules, the short hairs are curved inwards; it projects, and draws in occasionally a little white protuberance, not uncommon in marshy water.

148. *Leucophra Viriscens.*

Leucophra cylindracea, opaca, postice crassiore. Cylindrical, opake leucophra, the lower part much thicker than the upper part.

This is a large, pear shaped, greenish coloured animalculum, filled with opake molecules, and covered with short hairs, generally moving in a strait line. Found in salt water.

149. *Leucophra Viridis.*

Leucophra ovalis opaca. Oval, opake leucophra.

Though at first sight it may be taken for a variety of the leucophra viriscens, yet on a further examination, it differs in many particulars; it cannot lengthen and shorten itself in the same manner that does. It is also much smaller. Sometimes it is seen to be contracted in the middle, as if it was going to be divided in two.

150. *Leu-*

150. *Leucophra Burfata*.

Leucophra viridis, ovalis, antice truncata. Green oval leucophra, the fore-part truncated.

This is similar in many respects to the foregoing leucophra, it is a long oval, bulging in the middle, filled with green molecules, every where ciliated, except at the apex, which is truncated, and somewhat of the shape of a purse; the hairs larger, and sometimes collected in little fascicles. It is to be found in salt water.

151. *Leucophra Pofthuma*.

Leucophra globularis, opaca, reticulo pellucenti. Globular opaque leucophra, covered as it were with a pellucid net.

Was found in fetid salt water.

152. *Leucophra Aurea*.

Leucophra ovalis, fulva, utraque extremitate æquali obtusius. Oval yellow leucophra, both ends of it equally obtuse.

The little hairs are with difficulty discovered; it has, in general, a vehement rotatory motion.

153. *Leucophra Pertusa*.

Leucophra ovalis, gelatinosa, apice truncato obtusa, altera latera suffossa. Oval gelatinous leucophra, the apex obtusely truncated, one side sunk down.

Gelatinous, yellow, without any small or large molecules; the fore-part truncated, the hind-part brought nearly to a point, a kind of oval hole on one side. It was found in salt water.

154. *Leucophra Fracta*.

Leucophra elongata, sinuato angulata subdepressa. *Leucophra* long, with sinuated angles, rather flat.

The body is white, gelatinous, granulated, flat, changing it's form considerably.

155. *Leucophra Dilatata*.

Leucophra complanata, mutabilis, marginibus sinuatis. Smooth changeable leucophra, with a sinuated edge.

A gelatinous membrane, with a few grey molecules in the fore-part, and a great number in the hinder-part; it is sometimes dilated into a triangular form, with sinuated sides; at other times the shape is more irregular and oblong.

156. *Leu-*

156. *Leucophra Scintillans*.

Leucophra ovalis, teres, opaca viridis. Oval, round, opaque, green leucophra.

This animalculum is supposed to be ciliated, from its bright twinkling appearance, which probably arises from the motion it gives the water; it is nearly of an egg-shape. Was found in December among the lesser lemnæ.

157. *Leucophra Veficulifera*. Fig. 41, Plate XXV.

Leucophra ovata, interaneis veficularibus. Oval leucophra, with veficular intestines.

An animalculum that is a kind of mean between the orbicular and oval, very pellucid, with a defined dark edge and inside, containing some very bright veficles, or little bladders. The middle often appears blue, so that the little bright veficles seem set in a cerulean substance. Muller could never perceive any of those rays which are mentioned by Spalanzani; he confesses, however, that he once saw an individual like this environed with very small unequal shining rays.

158. *Leucophra Globulifera*.

Leucophra crystallina, ovato-oblonga. Crystalline leucophra, of an oblong oval shape.

The body is round, very pellucid, without molecular intestines, though at one edge it has three little pellucid globules; it is every-where beset with short hairs. It was found in a ditch where the *lemna minor* grows.

159. *Leucophra Pustulata.*

Leucophra ovato-oblonga, postice oblique truncata. An oblong oval leucophra, the lower end obliquely truncated.

The body is white, gelatinous, somewhat granulated; the lower part is truncated, as if an oblique section was made in an egg near the bottom. It is covered with little shining erect hairs, at the lower end a few bright pustules may be discovered. It is found in marshy waters.

160. *Leucophra Turbinata.*

Leucophra inversa conica, subopaca. *Leucophra* in shape like an inverted cone, and rather opaque.

It is a round pellucid body, somewhat of an acorn shape, with a pellucid globule at the lower end. Was found in stinking salt water.

161. *Leucophra Acuta.*

Leucophra ovata, teres, apice acuto, mutabilis, flavicans. Oval leucophra, round, with the apex acute, mutable, yellow.

Gela-

Gelatinous, mutable, and thick, the apex bright, the rest of the body crammed with an innumerable quantity of little spherules. It is sometimes drawn up into an orbicular shape, at other times one edge is sinuated. It was found in salt water.

162. *Leucophra Notata*.

Leucophra ovata, teres, puncto marginali atro. Oval leucophra, round, with a black point at the edge.

163. *Leucophra Candida*.

Leucophra hyalina, oblonga, altera extremitate attenuata, curvata. *Leucophra* of a talcy appearance, oblong, one end smaller than the other, and bent back.

The body membranaceous, flat, very white, with no visible intestines, if we except two oval bodies which are with difficulty perceived; the whole edge is ciliated. Found in an infusion of salt water.

164. *Leucophra Nodulata*.

Leucophra ovato-oblonga, depressa, serie nodulorum duplici. An oblong oval species of leucophra, with a double row of little nodules.

165. *Leu-*

165. *Leucophra Signata*.

Leucophra oblonga, subdepressa. Oblong subdepressed leucophra, with a black margin, filled with little molecular globules, but more particularly distinguished by a curved line in the middle, something in the shape of a long S; one end of this is at times bent into a small spiral. Common in salt water, in the months of November and December.

166. *Leucophra Trigona*.

Leucophra crassa, obtusa, angulata, flava. Thick, obtuse, angular, and yellow leucophra.

A triangular yellow mass, filled with unequal pellucid vesicles, one of which is much larger than the rest, the edge surrounded with little fluctuating hairs. It is not common. Was found in a marshy situation.

167. *Leucophra Fluida*.

Leucophra subreniformis, ventricosa. *Leucophra* somewhat of a kidney shape, but ventricose.

168. *Leucophra Fluxa*.

Leucophra sinuata reniformis. Reniform sinuated leucophra.

169. *Leu-*

169. *Leucophra Armilla*.

Leucophra teres annularis. Round annular leucophra.

170. *Leucophra Cornuta*. Fig. 42 and 43. Plate XXV.

Leucophra inverſe conica, viridis opaca. An inverted cone; green, opake.

It bears ſome reſemblance to the vorticella polymorpha and the vorticella viridis, and requires to be obſerved for ſome time before it's peculiar characters can be aſcertained; the body composed of molecular veſicles, of a dark green colour; for the moſt part it is like an inverted cone, the fore-part wide and truncated, with a little prominent horn, or hook, on both ſides, the hind-part being conical, every-where ciliated, the hairs exceeding minute; thoſe in the fore-part are three times longer than theſe, and moving in a circular direction. The hinder-part is pellucid, and ſometimes terminates in two or three obtuſe pellucid projections. The animalculum will at one moment appear oval, at another reniform, and ciliated on the fore-part; at another time the hairs are concealed. When the water evaporates, it breaks or diſſolves into molecular veſicles. It is found late in the year in marſhy grounds. Fig. 42, a the hinder-part pointed, it is obtuſe at b, Fig. 43, e the fore-part, g the cilia, f the horns, h the ſides.

171. *Leu-*

171. *Leucophra Heteroclita*. Fig. 44 and 45.

Leucophra cylindrica, antice obtusa, postice organo cristato duplici exfertili. Cylindrical leucophra, the fore-part obtuse, the hind-part furnished with a double-tufted organ, which it can thrust in or out at pleasure. To the naked eye it appears as a white point, in the microscope as a cylindrical body, the fore-part obtusely round, the middle rather drawn in, the lower part round, but much smaller than the upper part. With a large magnifying power the whole body is found to be ciliated. The intestines are very visible. It is represented in Fig. 44 as it generally appears, in Fig. 45 with the plumed organs. a the fore-part, b the hind-part, d the hooked intestines, ii the plumes, g g the sheaths from which they are projected.

XIII. TRICHODA.

Vermis inconspicuus, pellucidus, crinitus. An invisible, pellucid, hairy worm.

172. *Trichoda Grandinella*.

Trichoda sphaerica, pellucida, superne crinata. Spherical, pellucid, the upper part hairy.

A most minute pellucid globule, the intestines scarce visible, the top of it's surface furnished with two, three, or more short bristles, which are with difficulty seen, the animalculum extending,

and then withdrawing them in an instant. It is found in pure water, and in infusions of vegetables.

173. *Trichoda Cometa*. Fig. 46 and 47, Plate XXV.

Trichoda sphaerica, antice crinita, globulo appendente. Spherical, the fore-part hairy, with an appendant globule.

It is a pellucid globule, replete with bright intestines, the fore-part furnished with hairs, the hind-part with a pellucid appendant globule.

174. *Trichoda Granata*. Fig. 48, Plate XXV.

Trichoda sphaerica, centro opaco, periphæria crinata. Spherical, with an opaque center, the periphery hairy.

It resembles the *trichoda grandinella* and *trichoda cometa*. It has a darkish nucleus in the center; its intestines are imperceptible; short hairs on the edge.

175. *Trichoda Trochus*.

Trichoda subpiriformis, pellucida, antice utrinque crinita. *Trichoda* somewhat of a pear-shape, pellucid, each side of the fore-part distinguished by a little bunch of hairs.

176. *Trichoda Gyrimus.*

Trichoda ovalis teres crystallina, antice crinita. Oval, round, crystalline trichoda, the front hairy.

It is one of the smallest among the trichoda, the body smooth and free from hairs, except at the fore-part, where there are a few. Found in salt water.

177. *Trichoda Sol.* Fig. 65 and 66, Plate XXV.

Trichoda globularis, undique radiata. Globular trichoda, every-where radiated.

This splendid creature constitutes a new genus, but as we know of no more of the same kind, it is introduced here. It is a little crystalline round corpuscle, the upper part convex; it is beset with innumerable, diverging rays, which are longer than the body, proceeding from every part of its surface: in the inside are similar molecules. The body contracts and dilates itself, the animalculum remaining confined to the same spot. It was found in water in which there were other infusoria, and which had been kept for three weeks. It propagates by division, and is represented as dividing in Fig. 66.

178. *Trichoda Solaris.*

Trichoda sphæroidea, peripheria crinita. Spheroidal trichoda, with a few hairs round the circumference.

The

The body is bright, orbicular, with globular viscera in the middle of it; in many a moveable substance, something like the letter S, may be discovered; it has seldom more than seventeen hairs, which are disposed round the circumference; each of them is in length nearly equal to the diameter of the animalculum.

179. *Trichoda Bomba*. Fig. 67 and 68.

Trichoda mutabilis, antice pilis sparsis. Changeable, with a few hairs dispersed on the fore-part.

It is larger than the *trichoda granata*, and of a yellow colour; it is a thick animalculum, pellucid, and replete with a kind of clay molecules; it is very lively, moving about with so much velocity as to elude the sharpest sight and most pertinacious observer, sometimes appearing spherical, sometimes reniform, (kidney-shaped) sometimes as at Fig. 67.

180. *Trichoda Orbis*.

Trichoda orbicularis, antice emarginata crinita. Orbicular, the fore-part notched and hairy.

It in some respects resembles the former, but is larger; is orbicular, smooth, and pellucid, a little notched in the fore-part: the hairs, which are longer than usual, occupy this incision, the rest of the margin has no hairs; the whole is composed of vesicular molecules.

181. *Trichoda Urnula.* Fig. 64.

Trichoda urceolaris, antice crinita. This trichoda is in the form of a water pitcher, the fore-part hairy.

A membranaceous pellucid animalculum, the hind-part obtuse, the middle something broader, the fore-part truncated, filled with vesicular black molecules; the hairs in the fore-part are even and short. It's motion is slow.

182. *Trichoda Diota.*

Trichoda urceolaris, antice angustata, ora apicis utrinque crinita. Pitcher-shaped trichoda, the fore-part smallest, each edge of the upper-part of the mouth hairy.

The body is of a clay colour, and filled with molecules; the lower part spherical, the upper part cylindrical and truncated.

183. *Trichoda Horrida.*

Trichoda subconica antice latiuscula, truncata postice obtusa, setis radiantibus cincta. Trichoda somewhat of a conical form, the fore-part rather broad and truncated, the lower part obtuse, the body covered with radiating bristles.

184. Tri-

184. *Trichoda Urinarium*.

Trichoda ovata, rostro brevissimo crinito. Egg-shaped, with a short hairy beak.

185. *Trichoda Semiluna*.

Trichoda semiorbicularis, antice subtus crinita. Semiorbicular, the fore-part hairy underneath.

A pellucid smooth animalculum, resembling the figure of the moon in the first quarter.

186. *Trichoda Trigona*. Fig. 63.

Trichoda convexa, antice ciliata, postice erosa. Convex, the fore-part ciliated, the hind-part as it were gnawed off.

This is a triangular animalculum, a little convex on both sides, the fore-part acute, the hind-part a little broader. A notch is seen at a in the hind-part, b the ciliated fore-part, c a tube.

187. *Trichoda Tinea*.

Trichoda clavata, antice crinita, postice grossa. This is clubbed, the fore-part hairy, the hind-part large.

This animalculum is round, not very pellucid, resembling an inverted club, narrow before; it is also like some of the tinea.

188. *Tri-*

188. *Trichoda Nigra*.

Trichoda ovalis compressa, antice latior crinita. Oval compressed trichoda, the fore-part broader and hairy.

The body is opaque, when in violent motion it is black, when at rest one side is pellucid; the middle of the fore-part is furnished with little moveable hairs. It was found in salt water.

189. *Trichoda Pubes.* Fig. 61 and 62.

Trichoda ovato-oblonga gibba, antice depresso. An egg-shaped oblong bunch, fore-part depressed.

An animalculum with a bunch above the hind-part, marked with black spots, depressed towards the top, a little folded, and somewhat convex underneath; at least this is its appearance when in motion. Very minute hairs occupy the apex, but which are with difficulty seen, except when it is in the agonies of death, it then stretches them out with all its might from an arched chink at the top, moving them vehemently, and endeavouring as it were to draw in the last drop of water. Is found in water where the duck-weed grows, mostly in December. b the hairs, c the black globules, a the projecting bunch.

190. *Trichoda Floccus.*

Trichoda membranacea, antice subconica, papillis tribus crinitis. Membranaceous trichoda, the fore-part rather conical, three small papillæ project from the base, which are set with hairs.

191. *Trichoda Sinuata*.

Trichoda oblonga depresso, altero margine sinuato crinita, postice obtusa. An oblong depressed trichoda, one margin hollow and hairy, the lower end obtuse.

The intestines seem to be more lymphatic than molecular; it is of a yellow colour, the hollow edge is that which is ciliated. It was found in river water.

192. *Trichoda Præceps*.

Trichoda membranacea, sublunata, medio protuberante, extorsum crinita. Membranaceous trichoda, somewhat lunated, protuberant in the middle, a row of hairs on the outside.

A pellucid membrane, the fore-part formed into a kind of neck, one edge rises into a protuberance like a hump back, the other edge is convex.

193. *Trichoda Proteus*. Fig. 56, 57, 58, 59, 60, Plate XXV.

Trichoda ovalis, postice obtusa, collo elongata retractile, apice crinito. Oval trichoda, the lower part obtuse, with a long neck, which it has a power of contracting or extending.

Baker's Empl. for Micr. p. 340, 348.

This

This is the same animalculum which was dignified by Mr. Baker with the name of proteus, on account of its assuming a great number of different shapes, so as scarce to be known for the same animal in its various transformations; and indeed, unless it be carefully watched while passing from one shape to another, it will often become suddenly invifible.

When water, wherein any forts of vegetables have been infused, or animals preserved, has stood quietly for some days, or weeks, in any glass or other vessel, a slimy substance will be collected about the sides, some whereof being taken up with the point of a penknife, placed on a slip of glass, in a drop of water, and looked at through the microscope, will be found to harbour several kinds of little animals that are seldom seen swimming about at large. The insect we are treating of is one of these, and was discovered in such slime-like matter, taken from the side of a glass jar, in which small fishes, water-snails, and other creatures had been kept. Its body in substance and colour resembled a snail's; the shape thereof was somewhat elliptical, but pointed at one end, whilst from the other a long, slender, and finely-proportioned neck stretched itself out, and was terminated with a head, of a size perfectly suitable to the other parts of the animal.

194. *Trichoda Versatilis*.

Trichoda oblonga, postice acuminata, collo retractili, infra apicem crinito. Oblong trichoda, the hind-part acute, with a neck that it can extend or contract at pleasure, the under part of the extremity of the neck hairy.

It resembles in some measure the trichoda proteus, but the neck is shorter, and the apex less spherical, the hinder-part of the trunk acute. It lives in the sea.

195. *Trichoda Gibba*. Fig. 55.

Trichoda oblonga, dorso gibbera, ventre excavata, antice ciliata, extremitatibus obtusis. Oblong trichoda, with a bunch on the back, the belly hollowed out, the fore-part ciliated, both ends obtuse.

The body is pellucid, the upper-part swelled out, within it are numerous obscure molecules, and three large globules, the ends rather incline downwards; when the water begins to fail, a few minute hairs may be discovered about the head, and at the abdomen; the body then becomes striated longitudinally.

196. *Trichoda Foeta*.

Trichoda oblonga, dorso protuberante, antice ciliata, extremitatibus obtusis. Oblong trichoda, with the back protuberant, the fore-part ciliated, both ends obtuse.

The body is round and long, and when extended resembles a rolling-pin in shape, with the ends obtuse, and one shorter than the other; it can draw in the ends, and swell out the sides, so as to appear almost spherical.

197. *Trichoda Patens*. Fig. 54.

Trichoda elongata, teres, antice foveata, fovæ marginibus ciliata. This trichoda is long, round, in the fore-part it has a long hole, the edges of which are ciliated.

It is a long cylindrical animalculum, filled with molecules, the fore-part bright and clear, a long opening (a) near the top, which tapers to a point, and is beset with hairs. It is found of different lengths in salt water.

198. *Trichoda Patula*.

Trichoda ventricosa, subovata, antice canaliculata, apice & canaliculo crinito. Ventricose, rather inclining towards an oval figure, with a small tube at the fore-part, the upper end of the tube beset with hairs.

199. *Trichoda Foveata*.

Trichoda oblonga, latiuscula, antice corniculis micantibus, postice mutica. Oblong trichoda, rather broad, three little horns on the fore-part, the hinder-part beardless.

200. *Tri-*

200. *Trichoda Striata*.

Trichoda oblonga, altero margine cursum, sinuata et ciliata, utraque extremitate obtusa. Oblong trichoda, one edge rather curved, and also furnished with a row of hairs, both extremities obtuse.

It is a splendid animalculum, of a fox colour, and at first sight might be taken for a kolpoda. The body is oblong, the lower end is the largest, the body becoming smaller at that part where the hairs commence; it has a set of streaks which run from one end to the other, and at the abdomen a double row of little eggs, lying in a transverse direction. It was found in river water in December.

201. *Trichoda Uvula*. Fig. 53.

Trichoda planiuscula elongata, æqualis, antice crinita. Rather flat and long, of an equal size throughout, the fore-part hairy.

This animalculum is six times longer than it is broad, round, flexuous, of an equal size, the greater part filled with obscure molecules, the fore-part (a) rather empty, distinguished by an alimentary canal, and lucid globules near the middle c; short hairs occupy the margin of the fore-part, some are dispersed into a chink near the canal. Found in an infusion of hay, &c.

202. *Trichoda Aurantia.*

Trichoda subfinuata, ovata, antice patula, apice ad medium crinita. *Trichoda* somewhat sinuated, oval, the fore-part broad, the apex hairy to the middle.

It is of a gold colour, pellucid, and filled with a variety of vesicles.

203. *Trichoda Ignita.*

Trichoda ovata, apice acuminata, subtus fulcata, fulco crinito. Oval trichoda, the apex rather acute, the under part furrowed, the furrows hairy.

It is of a fine purple gold colour, somewhat of a reddish cast, pellucid, splendid, with a number of different-sized globules; the fore-part small, the hind-part obtuse, and having a very large opening, which runs as it were through the body.

204. *Trichoda Prisma.*

Trichoda ovata, subtus convexa, supra in carinam compressa, antice angustior. Oval trichoda, the under part convex, the upper part compressed into a kind of keel, the fore-part small.

It is very small; and so transparent, as not easily to be delineated; no hairs could be observed, and its form is singular.

205. *Tri-*

205. Trichoda Forceps.

Trichoda ovalis, antice forcipata, cruribus inæqualibus crinitis. Oval trichoda, with a pair of forceps at the fore-part, with unequal hairy legs.

A large animalculum, somewhat depressed, of a pellucid yellow colour, filled with molecules; in the lower part there is a black opake globule, the fore-part is divided into long lobes, one of these in the shape of a bill, (*falciformis*) and acute, the other is dilated, and obliquely truncated; both the apex and the edge of these are furnished with hairs of different lengths; it can open and shut these forceps, and cross them at pleasure; by this motion it sucks in the water. It was found in water that was covered with *lemna*, about the winter solstice.

206. Trichoda Forfex.

Trichoda ventrosa, antice forcipata, postice papilla duplici instructa. Ventrose trichoda, the fore-part formed into a kind of forceps, and two small protuberances.

One of the forceps of this animalculum is twice as long as the other, hooked, and ciliated. It was found in river water.

207. Trichoda Index.

Trichoda obovata, margine antico subtus crinito, alteroque apicis in digitum producto. Obovated trichoda, the under part
of

of the front margin hairy, the apex is formed by the fore-part, projecting like the finger on a direction-post. It was found in salt water.

208. *Trichoda S.*

Trichoda striata, antice ciliata, extremitatibus in oppositum flexis. Striated trichoda, the fore-part ciliated, the extremities bent in opposite directions.

A yellow animalculum, formed of two pellucid membranes, striated longitudinally; the lower end is obliquely truncated.

209. *Trichoda Navicula.*

Trichoda triquetra, antice truncata ciliata, postice acuta prominula. Three-cornered trichoda, the fore-part truncated and ciliated, the hind-part acute, and bent a little upwards.

It is crystalline, rather broad, the under-side towards the hinder-part convex, the fore-part broad, the apex nearly a straight line, the bent end pointed and turned upwards; it has a kind of longitudinal keel running down the middle.

210. *Trichoda Succifa.*

Trichoda ovalis depressa, margine crinito, postice in crura inæqualia crosa. Flattened oval trichoda, the edge hairy, the hinder-part hollowed out so as to form two unequal legs.

211. *Tri-*

211. *Trichoda Sulcata*.

Trichoda ovato-ventricosa, apice acuminata, sulco ventrali, utrinque crinito. Ovated ventricose trichoda, the apex acute, a furrow at the abdomen, both sides of it ciliated.

212. *Trichoda Anas*. Fig. 49.

Trichoda elongata, apice colli subtus crinito. Long, the apex of the neck underneath hairy.

A smooth animalculum, five times broader than it is long, filled with darkish molecules; a bright neck *bc*, under the top of the neck at *d* there shine a few unequal hairs. Its motions are languid. It is found in pure water.

213. *Trichoda Barbata*.

Trichoda elongata, teres, subtus ab apice ad medium crinita. *Trichoda* long, round, the under-part, from the apex to the middle, hairy.

This animalculum is round, somewhat linear, both ends obtuse, the fore-part narrower, forming as it were a kind of neck; under this is a row of fluctuating hairs. The trunk is full of grey molecules.

214. *Tri-*

214. *Trichoda Farcimen.* Fig. 50 and 52, Plate XXV.

Trichoda elongata, torulosa, fetulis cincta. Long and thick trichoda, surrounded with small bristles.

The body is long, round, pellucid, and covered with very minute hairs; it has also about the body a great number of mucid vesicles.

215. *Trichoda Crinita.*

Trichoda elongata, teres, undique ciliata, subtus ad medium usque crinita. Long trichoda, round, every-where ciliated, the under-part also hairy as far as the middle.

216. *Trichoda Angular.*

Trichoda angulata, apice crinita. Angular, the apex hairy.

This animalculum is long, more convex than most of it's kind, divided, by a kind of articulation, into two parts, of equal breadth, but differing in length, the fore-part shorter than the hind-part, the apex furnished with short waving hair, indistinct molecules within-side, no hair on the hind-part.

217. *Trichoda Linter.* Fig. 51, Plate XXV.

Trichoda ovato oblonga, utraque extremitate prominula. The shape of an oblong egg, with prominencies at both extremities.







Both extremities of the body are raised, so as to be convex at bottom, the upper part depressed like a boat; sometimes the whole body whirls about. It differs from itself at different ages. Is found in an infusion of old grass.

218. *Trichoda Paxillus*.

Trichoda linearis depressa, antice truncata crinitaque, postice obtusa. Linear flat trichoda, the fore-part truncated and hairy, the hinder-part obtuse.

A long animalculum, full of grey molecules, the fore-part rather smaller than the hind-part, and furnished with minute hairs. Was found in salt water.

219. *Trichoda Vermicularis*. Fig. 1, Plate XXVI.

Trichoda elongata, cylindracea, collo brevi, apice crinito. Long cylindrical trichoda, with a short neck, the apex hairy.

Gelatinous, the fore-part pellucid, the hind-part full of molecules. It was found in river water. It is represented in different appearances in the figure, a the neck, b the hairs, c a little vesicle in the hinder-part.

220. *Trichoda Melitea*. Fig. 2, Plate XXVI.

Trichoda oblonga, ciliata, colli dilatabilis, apice globoso, pilifero. Oblong ciliated trichoda, with a dilatable neck, the apex globular, and surrounded with hairs, the edge is ciliated, and a

kind of peristaltic motion may be perceived. It is very rarely found, and even then in salt water. a the neck, b the globular apex, c the body ciliated.

222. *Trichoda Fimbriata.* Fig. 2, Plate XXVI.

Trichoda obovata, apice crinita, postice oblique truncata serrata. Obovated trichoda, the apex hairy, the hinder-part obliquely truncated and serrated.

223. *Trichoda Camelus.*

Trichoda antice crinita, crassiuscula medio utrinque emarginata. Thick, and the fore-part hairy, with notches on the middle and each side.

The fore-part of the body is ventricose; the back is divided, by an incision in the middle, into two tubercles, the lower part of the belly sinuated. Languid in it's motion. Is found, though not often, in infusions of vegetables.

224. *Trichoda Augur.*

Trichoda oblonga, vertice truncata, antico corporis margine, superne pedata, inferne setosa. The body oblong, depressed, pellucid, and filled with molecules; the vertex truncated, the fore-part forming a small beak, underneath are three feet; beyond these, towards the hinder-part, it is furnished with bristles.

225. *Tri-*

225. *Trichoda Pupa.*

Trichoda cucullata, fronte crinita, cauda inflexa. This trichoda is hooded, the front hairy, the tail inflected.

At first sight it resembles the pupa of the gnat. The body is rather round, pellucid, and may be described as consisting of three parts; the head, which is broad, and as it were hooded, the top furnished with very small hairs, a transparent vesicle occupies the lower region of the head, and a certain production hangs over the breast from the base of the head, resembling the sheath of the feet in the pupa of the gnat.

226. *Trichoda Lunaris.*

Trichoda arcuata, teres, apice crinita, cirro caudali inflexo. Arched trichoda, round, the apex hairy, the tail bent.

This animalculum bends itself in the form of an arch, is round and crystalline, the hind-part somewhat smaller than the fore-part; the intestines are with difficulty distinguished. The edge of the back, and the part near the tail, are bright and clear.

227. *Trichoda Bilunis.*

Trichoda arcuata, depressa, apice crinita, cauda bifeta. Arched flattened trichoda, the apex hairy, two little bristles proceeding from the tail.

228. *Trichoda Rattus*. Fig. 4, Plate XXVI.

Trichoda oblonga, carinata, antice crinita, postice seta longissima. Oblong trichoda, with a kind of keel, the fore-part hairy, a very long bristle proceeding from the hinder-part. a the mouth, b a small knob at the bending of the tail, c the tail.

229. *Trichoda Tigris*.

Trichoda subcylindrica, elongata, apice crinita, cauda setis duabus longis. This trichoda is long, and somewhat cylindrical, the apex hairy, the tail divided into two long bristles.

It differs from the preceding in two particulars; first, that of the tail; second, in a kind of incision in the body, at some little distance from the apex.

230. *Trichoda Pocillum*. Fig. 5 and 6, Plate XXVI.

Trichoda oblonga, antice truncata, crinita, cauda articulata, bifeta. Oblong trichoda, the fore-part truncated and hairy, the tail articulated, and divided into two bristles.

The body is cylindrical, pellucid, muscular, capable of being folded up, seems as if it were formed of two; the interior one, which is filled with molecules, has also an orbicular muscular appendage, which it can shut and open, and that forms the mouth. The exterior one is membranaceous, dilated, pellucid, and marked with transverse streaks; the animalculum can protrude

or

or draw in the orbicular membrane at pleasure. In some there are four articulations to the tail, in others five; it has two pair of bristles, or projecting parts, one placed at the second joint, the other at the last. It has been found very often in marshy waters. In Fig. 6 it is seen with the mouth open, in Fig. 5 with it shut, a the jaws, b the first bristles, c the second pair, d the spine at the tail.

231. *Trichoda Clavus.*

Trichoda antice rotundata, crinita postice acuminato-caudata. The fore-part round and hairy, the hind-part furnished with a sharp-tail. This animalculum is not much unlike in shape to a common nail.

232. *Trichoda Cornuta.*

Trichoda supra convexa, subtus plana, apice crinita, cauda lineari simplici. *Trichoda* with the upper part convex, the under side plain, the apex hairy, the tail linear and simple.

To these characters we may add, that the body is membranaceous, elliptical, crammed with molecules, the fore-part lunated, the hinder-part round, and terminated with a tail as long as the body.

233. *Tri-*

233. *Trichoda Gallina*.

Trichoda elongata, antice finuata, fronte crinita, cauda pilosa. Long trichoda, the fore-part finuated, the front hairy, the tail formed of small hairs.

The body flat, of a grey colour, with seven large molecules and globules within it, the front obtuse, and set with hairs, the hinder-part terminating in a tail, which is formed of very fine hairs. It was found in river water.

234. *Trichoda Musculus*. Fig. 7, Plate XXVI.

Trichoda ovalis antice crinita, postice subtus caudata. Egg-shaped, the fore-part hairy, the tail projecting from the under-part.

A smooth egg-shaped animalculum, with a double margin, or line, drawn underneath it, the fore-part narrow, and furnished with short hairs that are continually playing about; underneath the hind-part is a small tail. It is furnished with molecular entrails, and moves slowly. Is found in infusions of hay, which have been kept for some months. a the head, b the tail.

235. *Trichoda Delphis*.

Trichoda clavata, fronte crinita, cauda acuminata, subreflexa. Clubbed trichoda, the front hairy, the tail small, and rather bent upwards.

It is smooth and pellucid, the fore-part dilated into a semicircle, decreasing in breadth towards the tail; the hairs stand as rays from the semicircular edge at the front, one edge is sometimes contracted. It is to be found in river water.

236. *Trichoda Delphinus*. Fig. 8, Plate XXVI.

Trichoda oblonga, antice crinita, postice cauda reflexa truncata. Oblong, the fore-part hairy, in the hind-part is the tail, which is turned back, the end of it truncated.

A pellucid, smooth, egg-shaped animalculum; the hind-part is produced into a tail about half the length of the body, dilated at the upper end, and truncated; it is always bent upwards.

In the inside are vesicles of an unequal size; it sometimes moves on its belly, sometimes on one side; the tail seldom varies in its position. Was found in hay that had been infused for some months. a the hairs on the fore-part, b the tail.

237. *Trichoda Clava*.

Trichoda clavata, fronte crinita, cauda reflexili. The club trichoda, the fore-part hairy, the tail turned back.

The fore-part is thick, the hind-part narrow, both extremities obtuse, pellucid and replete with molecules, the hind-part bent downwards towards the middle.

238. *Tri-*

238. *Trichoda Cuniculus.*

Trichoda oblonga, antice crinita, postice subacuminata. Oblong, the fore-part hairy, the hind-part rather acute, filled with molecules and black vesicles.

239. *Trichoda Felis.* Fig. 9, Plate XXVI.

Trichoda curvata, grossa, antice angustior, postice in caudam attenuata, subtus longitudinaliter crinita. Curved trichoda, large, the fore-part small, the hinder-part gradually diminished so as to form a tail, the under-side beset longitudinally with hairs. a the head, b the tail, c the hairs.

240. *Trichoda Piscis.* Fig. 13 and 14, Plate XXVI.

Trichoda oblongata, antice crinita, postice in caudam exquisitam attenuata. Oblong, the fore-part hairy, the hind-part terminating in a very slender tail. Smooth and pellucid, much longer than it is broad, but of nearly an equal breadth throughout, filled with yellow molecules, the fore-part obtuse, the hind-part exquisitely slender and transparent, the upper side is convex. a the fore-part, b the tail.

241. *Trichoda Larus.*

Trichoda elongata, teres, crinita, cuspidi caudali duplici. Long round trichoda, beset with hairs, the tail divided into two points. See *Zoologia Danica*.

242. *Tri-*

242. *Trichoda Longicauda.* Fig. 10, Plate XXVI.

Trichoda cylindracea, antice truncata et crinita, cauda elongata, biarticulata & bifeta. Cylindrical trichoda, the fore-part truncated and set with hairs, the tail long, with two joints, and terminated by two bristles. a the hairs at the mouth, d the oesophagus, c the articulation of the tail, f the bristles.

243. *Trichoda Fixa.*

Trichoda sphaerica, periphæria crinita, pedicello solitario. Spherical trichoda, the circumference set with hairs, and a little solitary pedicle projecting from the body.

244. *Trichoda Inquilinus.*

Trichoda vaginata, folliculo cylindrico hyalino, pedicello intra folliculum retortili. Sheathed trichoda, in a cylindrical transparent bag, and a little pedicle bent back within the bag. See Zool. Dan. prodr. addend. p. 281.

245. *Trichoda Ingenita.*

Trichoda vaginata, folliculo depresso, basi latiore sessilis. Sheathed trichoda, the bag depressed, the base broadest.

The animalculum that is contained in this sheath is funnel-shaped; a hair, or hairs, may be perceived on each side of the mouth of the funnel. It can extend or contract itself freely in

the bag, without even touching the sides, the tail resting on the base thereof. It was found in salt water.

246. *Trichoda Innata*. Fig. 11, Plate XXVI.

Trichoda vaginata, folliculo cylindrico, pedicello extra folliculum. Sheathed trichoda, with a cylindrical bag, the pedicle passing through and projecting beyond the bag. These characters distinguish it sufficiently from the preceding one. b the animal-culum in the sheath, d the tail.

247. *Trichoda Transfuga*.

Trichoda latiuscula, antice crinita, postice setosa, altero latere sinuata, altero mucronata. Broad trichoda, the fore-part hairy, the hinder-part full of bristles, one side sinuated, the other pointed. See Zool. Dan. prod. addend. p. 281.

248. *Trichoda Ciliata*.

Trichoda ventricosa, postice crinibus pectinata. See Zool. Dan. Icon. tab. 73, Fig. 13, 15.

249. *Trichoda Bulla*.

Trichoda membranacea, lateribus inflexis, antice & postice crinita. Membranaceous trichoda, the sides bent inwards, the fore and hind-part are both furnished with hairs; it differs only by the last circumstance from the *burfaria bulla*.

250. Tri-

250. *Trichoda Pellionella*.

Trichoda cylindracea, antice crinita, postice setosa. Cylindrical, the fore-part hairy, the hinder-part furnished with bristles.

This trichoda is rather thick in the middle, pellucid, with a few molecules here and there, the sides obtuse, the fore-part ciliated, the hairs very fine, the hind-part terminating in a kind of bristles.

251. *Trichoda Cyllidium*. Fig. 15, Plate XXVI.

Trichoda ovata, apice hiante, basique crinita. Egg-shaped, the apex gaping, the base hairy.

Pellucid, replete with globules of different sizes, in the hind-extremity; the fore-part narrower, without any footsteps of an external organ. It vacillates upon the edge, commonly advancing on its flat side, continually drawing up water; it then gapes, opens into a very acute angle, almost to the middle of the body. It is difficult to be perceived, as it effects this in an instant. a the mouth, b the hairs or bristles, which it extends when in agonies.

252. *Trichoda Curfor*.

Trichoda ovata, antice crinita, postice duplici pilorum strictorum & curvorum fasciculo. Oval trichoda, the fore-part hairy,

the hinder-part furnished with two fascicles of straight and curved hairs.

The body flat, and filled with molecules; in the fore-part there is an oblong empty space, into which, under certain circumstances, we may see the water as it were sucked in.

253. *Trichoda Pulex*. Fig. 12, Plate XXVI.

Trichoda ovata, antice incisa, fronte & basi crinita. Egg-shaped, with an incision in the fore-part, the front and the base hairy. a the anterior, b the posterior part, c the incision.

254. *Trichoda Lynceus*. Fig. 16, Plate XXVI.

Trichoda subquadrata, rostro adunco, ore crinito. Nearly square, with a crooked beak, the mouth hairy.

At first sight it does not appear very dissimilar to some of the monocoli. The body is membranaceous, and as it were compressed, being broad without thickness, stretched out into a beak above, the lower part truncated; under the beak is a little bundle of hairs, the lower edge bends in and out, and is girt round with a few bristles. The intestines are beautifully visible, a small bent tube goes from the mouth to the intestines in the middle of the body; these, as well as the tube, are in frequent agitation; another tube is also perceivable between the fore and hind edge. It is filled with a blue liquor. a the beak, b the mouth, c the base.

252. Tri-

255. *Trichoda Erofa.*

Trichoda orbicularis, antice emarginata, altero latere crinita, postice fetosa. Orbicular trichoda, the fore-part notched, one side set with hairs, the hinder-part with bristles.

256. *Trichoda Rostrata.*

Trichoda depressa, mutabilis, flavescens, ciliis longis fetisque pediformibus. Depressed trichoda, mutable, yellow, with long ciliated hairs, and feet tapering to a point.

The body depressed, both the feet and hairs are within the margin, the feet are four in number, one of them is longer than the rest. The figure of the body is for the most part somewhat triangular, the apex formed into a kind of obtuse beak; the beak is sometimes drawn in so that the animalculum then appears altogether orbicular. Found in water where duck-weed has been kept.

257. *Trichoda Lagena.*

Trichoda teres, ventricosa, rostro producta, postice fetosa. Round ventricose trichoda, with a long neck, the lower end set with bristles.

258. Tri-

258. *Trichoda Charon*. Fig. 17 and 18, Plate XXVI.

Trichoda cymbiformis fulcata, antice et postice crinita. Boat-shaped trichoda with furrows, the fore and hind-parts both hairy.

The body is oval; it resembles a boat both in shape and motion, the upper part hollowed, the under part furrowed and convex, the stern round, with several hairs projecting from it. Several hairs may also be seen on one side. Was found in salt water. a the head, b the tail; d, Fig. 18, a pellucid bubble that is sometimes to be perceived.

259. *Trichoda Cimex*. Fig. 19, Plate XXXI.

Trichoda ovalis, marginibus lucidis, antice et postice crinita. Oval trichoda, with a lucid margin, both the fore and hind-part hairy.

It is about the size of the trichoda lynceus, an oval body, the back convex, the belly flat, an incision in the edge of the fore-part; the edges of this incision are seen to move. Its intestines are pellucid and ill-defined.

It both swims and walks. When it meets with any obstacles, four small bristles, which are fixed underneath, come into view; these it uses as feet. a the hairs in the fore-part, b the bristles at the hind-part, d the back, e two small projecting hairs.

260. Tri-

260. *Trichoda Cicada.*

Trichoda ovalis, marginibus obscuris, antice & subtus crinita, postice mutica. Oval trichoda, with an obscure margin, the fore-part underneath set with hairs, the hinder-parts beardless.

It does not differ considerably from the preceding, though M. Muller has pointed out some shades by which they may be discriminated.

XIV. KERONA.

Vermis inconspicuus corniculatus. An invisible worm with horns.

261. *Kerona Raftellum.*

Kerona orbicularis membranacea, nuda, corniculis in tota pagina. Membranaceous orbicular kerona, with one projecting point, the upper surface covered with small horns. There are three rows of horns on the back, which nearly occupy the whole of it. It was found in river water.

262. *Ke-*

262. *Kerona Lyncaffer.*

Kerona subquadrata. roſtro obtuſo, diſco corniculis micantibus. This ſpecies of *kerona* is rather ſquare, the diſc furniſhed with ſhining horns. See Zool. Dan. prod. add. p. 281.

263. *Kerona Hiſtrio.* Fig. 20, Plate XXVI.

Kerona oblonga, antice punctis mucronatis nigris, poſtice pin-
nulis longitudinalibus, inſtructa.

It is an oblong membrane, pellucid, with four or five black points in the fore-part, which are continually changing their ſituation, thick ſet with ſmall globules in the middle, among which four larger ones are ſometimes perceived, theſe are probably eggs; in the middle ſpace of the hind-part are ſome longitudinal ſtrokes reſembling bristles; they do not ſeem to project beyond the body. b the horns, c ſome hairs, d a ſolitary horn, e a large globule, f ſome bristles.

264. *Kerona Cypris.* Fig. 21, Plate XXVI.

Trichoda obovata, verſus poſtica ſuperne ſinuata, antice crinita. Egg-shaped, towards the hind-part ſinuuated, the fore-part hairy.

This animalculum is compreſſed, and ſomething in a pear-ſhape, the fore-part broad and blunt, the front is furniſhed with ſhort hairs a, or little vibrating points inſerted under the edge, ſhorter

in the hind-part, partly extended straight, partly bent down; the motion is retrograde. It is found in water which is covered with lemna.

265. *Kerona Haustrum*.

Kerona orbiculata, corniculis mediis, antice membranacea ciliata, postice setosa. Orbicular *kerona*, the horns in the middle, the fore-part membranaceous and ciliated, at the hinder-part there are several bristles.

266. *Kerona Hautellum*.

Differs from the preceding only in having the hinder-part without any bristles.

267. *Kerona Patella*. Fig. 22 and 23, Plate XXVI.

Kerona univalvis, antice emarginata corniculata, postice setis flexilibus pendulis. With one valve, orbicular, crystalline, the fore-part somewhat notched, the fleshy body lies in the middle of the shell; above and below are hairs, or horns, of different lengths, jutting out beyond the shell, and acting instead of feet and oars, some of which are bent; the superior ones constitute a double transverse row. a the fore-part, b the horns, d a lunated figure in the shell, c a pulpy body, f bristles at the hinder-part.

268. *Kerona Vannus*.

Kerona ovalis, subdepressa, margine altero flexo, opposito ciliato, corniculis anticis, setisque posticis. Oval and rather flat *kerona*, one edge bent, the opposite edge ciliated, the front furnished with horns, the hinder-part with bristles.

269. *Kerona Pullaster*. Fig. 24 and 25, Plate XXVI.

Kerona ovata, antice sinuata, fronte crestatâ, basi crinita. Oval, the fore-part sinuated, a crest on the front, the base hairy.

It agrees with the *trichoda pulex* in many particulars, but the upper part is pellucid, without any black molecules, the front truncated, the whole superficies of the head covered with hair, and the fore-part sinuous. a the horns, b the hairs at the hinder-part, c the cilia of the front.

270. *Kerona Mytillus*. Fig. 29, Plate XXVI.

Kerona subclavata, utraque extremitate latiori, hyalina ciliata. Rather clubbed, broad at both extremities, clear and ciliated.

A large animalculum, the fore and hind-part rounded, very pellucid and white, dark in the middle, with black intestines, intermixed with a few pellucid vesicles. Both extremities seem as it were composed of two thin plates. The fore-part is ciliated, the hairs short, lying within the margin; it is also ornamented
with

with two little horns, erected from an obscure mass; with these it agitates the water, forming a little whirlpool. The hind-part is ciliated, and furnished with two bristles, that stretch out beyond the margin. a the horns, b the fore-part ciliated, c the hind-part, d projecting bristles.

271. *Kerona Lepus*.

Kerona ovata, apice crinito, basi setosa. Egg-shaped, the fore-part hairy, the base furnished with bristles.

The body is egg-shaped, compressed, pellucid, crowned with short waving hairs, the base terminating with bristles.

272. *Kerona Silurus*.

Kerona oblonga, antice & postice crinita, dorso ciliato. Oblong, the fore and hind-part hairy, the back ciliated.

An oval smooth animalculum, something crooked and opaque, a fascicle of vibrating hair on the fore-part; the hind-part, or sharp tail, furnished with unequal moveable rows of hairs, the back is also ciliated; these hairs produce a rotatory motion; in the inside are some unequal, lucid, opaque points. The figure varies from oval to oblong, the filaments of the conferva are often entangled in the tail.

273. *Kerona Calvitium.*

Kerona latiuscula, oblonga, antice corniculis micantibus. Rather broad, oblong, with glittering horns on the fore-part.

The body is rather broad and flat, both sides obtuse, filled with black molecules, and more particularly a dark spot near the hinder-part; the interjacent vesicles are pellucid, no hairs on the fore-part, but instead thereof two little moveable horns, and from three to five moveable black points, a few short bristles at the hind-part. Found in the infusions of vegetables.

274. *Kerona Pustulluata.*

Kerona ovalis convexa, postice altero margine sinuata, utraque extremitate crinita, corniculisque anticis. Oval convex *kerona*, one edge of the hinder-part sinuated, both ends set with hairs, and some horns placed on the fore-part.

This animalculum was found in salt water.

XV. HIMANTOPUS.

Vermis inconspicuus, pellucidus, cirratus. A pellucid, invisible, cirrated * worm.

275. *Hi-*

* That is, furnished with a tuft or lock of hair.

275. *Himantopus Acarus.* Fig. 27, Plate XXVI.

Himantopus ventrosus, pollice cirratus, antice acuminatus.
 Ventrose himantopus, the hinder-part cirrated, the fore-part sharp.

It is a lively, conical, ventricose animalculum, full of black molecules, the fore-part bright and transparent. The apex is more or less attenuated, at the will of the little creature, with rows of long hairs, like so many rays underneath; four locks of hair, or feet, long and crooked, proceed from the belly; it is continually moving these and the other hairs in various directions, it has the same circular motion in the same place. It is found, though seldom, where there is lemna. a the apex, b the ciliated part, c the feet.

276. *Himantopus Ludio.* Fig. 26, Plate XXVI.

Himantopus cirrata, supra crinita, cauda fursum extensa.
 Curled himantopus, the upper part hairy, the tail extended upwards.

This is a lively and diverting animalculum, smooth, pellucid, full of little points, the fore-part clubbed, and a little bent, the hind-part narrow, the base obliquely truncated, terminating in a tail stretched out transversely. The top of the head, and the middle of the back b, furnished with long vibrating hairs; from the
 side

side of the head hang three moveable and flexible curls a, distant from each other. When the animalculum is in motion, the tail is drawn tight, and extended upwards; and often appears as if it was cleft. It is curled up when the little creature is at rest.

277. *Himantopus Sannio.*

Himantopus incurvata, supra ciliata, infra crinita. Crooked himantopus, the upper part ciliated, the under part hairy.

It is very much like the *himantopus ludio*, the cilia are longer than the hairs, and are continually vibrating; it has also two moveable curls hanging on both sides the head. Is found but seldom, and then generally in water where the *lemna* vegetates.

279. *Himantopus Volutator.*

Himantopus lunatus, antice cirratus. Lunated himantopus, the fore-part hairy.

A very lively animalculum, of the shape of a crescent, with some visible crystalline points, the convex part furnished with a row of hairs, which are longest towards the tail; underneath are four feet. It often turns round swiftly in a circular direction.

280. *Himantopus Larva.*

Himantopus elongatus, medio cirratus. Long himantopus, cirrated in the middle.

By it's motion it resembles the himantopus ludio, but differs from it in figure and situation of the parts: The body is rather depressed and long, the hinder parts acute, and generally curved, pellucid, filled with granular molecules.

281. Himantopus Charon.

Himantopus cymbæformis fulcata, in fovea ventrali cirrata. Boat-shaped furrowed himantopus, the hollow part of the belly cirrated.

An oval pellucid membrane, the fore-part hairy, furrowed longitudinally, each side bent up so as to form an intermediate hollow place, or belly, crammed with grey molecules; beneath the middle it has several bent diverging rows of hairs; no hairs on the hinder-part. Rarely to be found, and then in sea-water.

282. Himantopus Corona.

Himantopus semiorbiculata, depressa, in utraque pagina cirrata. Semiorbicular himantopus, flattened, both sides cirrated.

A membranaceous lamina, very thin, very pellucid, crysalline, semilunar; the edge of the base thick set with molecular intestines; the other angle, or fore-part, furnished with short hairs, or a kind of mane; towards the hind part three equal curved hairs, or spines.

XVI. VORTICELLA.

Vermis contractilis, nudus, ciliis rotatoriis. A worm capable of contracting or extending itself, naked, with rotatory cilia.

283. Vorticella Viridis. Fig. 31, Plate XXVI.

Vorticella cylindracea, uniformis, viridis opaca. Cylindrical, uniform, green, and opaque.

To the naked eye it appears as a small green point, through the microscope as an opaque corpuscle, of a dark-green colour, cylindrical, obtuse at both extremities, yet rather thicker in the fore-part a; very simple, destitute of limbs, not changing its figure. Notwithstanding its simplicity, the continual motion into which it puts the water gives room to suspect that it is furnished with an invisible rotatory instrument, it moves sometimes circularly, sometimes in a straight line. a the fore-part, b the hind-part, c short hairs.

284. Vorticella Sphæroïda.

Vorticella cylindrico-globosa, uniformis, opaca. A globous cylinder, uniform and opaque.

To the naked eye it appears little more than a point swimming about in the water; but with the microscope as a globular mass, of a dark-green colour; they occasion a vehement motion in the adjacent

adjacent water, very short hairs, which are probably the cause thereof, may be perceived.

285. *Vorticella Cincta*. Fig. 30, Plate XXVI.

Vorticella trapeziformis, nigro-viridis, opaca. This vorticella is in the form of a trapezium, of a blackish green colour, and opaque.

It is of an irregular figure, invisible to the naked eye, ciliated on every side, the hairs all moveable, and longer on one side than on the other. It sometimes assumes an oval shape, and appears girt round with a transversal keel.

286. *Vorticella Lunifera*.

Vorticella viridis, postice lunata, medio margine mucronato. Green vorticella, the hinder-part lunated, with a point in the middle, projecting from the edge.

The fore-part obtuse, the base broad, and hollowed away like a crescent, with a protuberance in the middle of the concave part, shorter than the horns or points of the crescent; the fore-part is ciliated. It is found in salt water.

287. *Vorticella Burfata*. Fig. 32, Plate XXVI.

Vorticella viridis, apertura truncata, papillaque centrali. Green vorticella, the aperture truncated, with a central papillary projection.

Ventricose, crammed with molecules, the fore-part truncated, and both sides of it, c c, pellucid; in the center of the aperture there is a prominent papilla or nipple b, which, when the animalculum is at rest, appears notched; the edge a a' of the aperture is surrounded with cilia; these are sometimes all erected, shining, and in motion, or part bent back and quiescent, and part in motion; sometimes a few of them are collected together, and turned back like little hooks, one on each side. Found in salt water. a the cilia, b the projecting papilla, c the pellucid space at the fore-part.

288. *Vorticella Varia*.

Vorticella cylindrica, truncata, opaca, nigricans. Cylindrical, truncated, opaque, blackish-coloured vorticella, the fore-part ciliated.

289. *Vorticella Sputarium*.

Vorticella ventrosa, apertura orbiculari, ciliis longis raris excentricis. Ventrose vorticella, with an orbicular aperture, and long hairs radiating as from a center.

This

This is a singular animalculum, even among those where all are singular; viewed sideways it is sometimes cylindrical, though somewhat tapering towards the hinder-part, with a broad pellucid edge; viewed from the top it has sometimes a broad face, or disc, furnished with radiating hairs, the under part contracted into a globular shape, of a dark-green colour, and filled with small grains. It was found in October with the lesser lemna.

290. *Vorticella Polymorpha*. Fig. 33, 34, 35, Plate XXVI.

Vorticella multiformis, viridis, opaca. Many-shaped vorticella, green, opaque.

To the naked eye it appears as a most agile green point; when viewed by the microscope, it puts on every moment so many and such various forms, that they can neither be exhibited to the eye by drawings, nor described by words; it is truly one of the wonders of nature, astonishing the mind, fatiguing the eye, and continually exciting the spectator to ask,

“Quo teneam vultus mutantem protea nodo?”

Fig. 33, 34, 35, represent it in three different forms; a the fore-part, g the hind-part, c the fore-part simple, d the fore-part turned in or doubled, the body is granulous, a series of pellucid points is sometimes to be observed.

291. *Vorticella Multiformis*.

Vorticella viridis, opaca, varia, veficulis fparfis. Green, opake, variable vorticella, with veficles fattered about the body.

This is fo. like the preceding one, that it needs no further defcription. Is found in falt water, and the veficles are larger.

292. *Vorticella Nigra*. Fig. 36 and 37, Plate XXVI.

Vorticella trochiformis nigra. Top-fhaped black vorticella.

To the naked eye they prefent themfelves as fmall black points fwimming on the water; through the microfcope it appears as a little conical corpufcle, opake, obtufe, and ventricofe at one extremity, the other acute; when it extends the extremities, two little white hooks come into fight, by their affiftance it moves in the water, and it is probable, from fome circumftances, that they inclofe a rotatory organ. It is in continual motion, vacillating on the top of the water. Is found in Auguft, in meadows that are covered with water. a the rotatory organ, b the two fmall hooks, c the acute end.

293. *Vorticella Cucullus*.

Vorticella elongata, teres, apertura oblique truncata. This vorticella is long, round, the aperture or mouth obliquely truncated.

This vorticella may be ranked among the larger ones, as it is visible to the naked eye. The body is somewhat conical, of a dirty red colour; its shape has been compared to that of a grenadier's cap.

294. *Vorticella Utriculata.*

Vorticella viridis, ventricosa, productilis, antice truncata. Green vorticella, ventricose, the belly capable of being lengthened or shortened, the fore-part truncated, much in the shape of a common water-bottle, the neck sometimes very long, at others with scarce any at all, and is filled with green molecules.

295. *Vorticella Ocreata.*

Vorticella subcubica, infra in angulum obtusum producta. This vorticella is somewhat of a cubical figure, the under part bent in an obtuse angle.

It is a very singular animalculum, being in shape like the lower part of a boot; the apex of the upper part, or leg, is truncated and ciliated, the heel pointed, the foot round. It is an inhabitant of rivers, though very rarely to be met with.

296. *Vorticella Valga.*

Vorticella cubica, infra divaricata. Cubical vorticella, the lower part divaricated.

This

This is filled with grey molecules, and is as broad as it is long, the apex truncated and ciliated, both angles of the base projecting outwards, one somewhat like a wart, the other like a finger. Found in marshy waters.

297. *Vorticella Papillaris.*

Vorticella ventricosa, antice truncata, papilla caudali & laterali hyalina. Ventricose vorticella, the fore-part truncated, a papillary tail, and a splendid papillary excrescence on the side. Is an inhabitant of marshes, where the *conferva nitida* is met with.

298. *Vorticella Sacculus.*

Vorticella cylindracea, apertura repanda, margine reflexo. Cylindrical vorticella, the aperture broad and flat, the edge turned down.

A thick animalculum, every-where of an equal diameter, and filled with molecules; the edge of the mouth bent back, the hinder-part obtuse, sometimes notched and contracted, cilia to be seen on both sides the mouth.

299. *Vorticella Cirrata.*

Vorticella ventrosa, apertura sinuata, cirro utrinque ventrali. Ventrose vorticella, the aperture sinuated, two tufts of hair on each side of the belly. It is an inhabitant of the water in ditches.

300. *Vor-*

300. *Vorticella Nafuta*. Fig. 38, 39, Plate XXVI.

Vorticella cylindracea, crateris medio mucrone prominente.
Cylindrical, with a prominent point in the middle of the cup.

An animalculum that is invisible to the naked eye; but when it is armed with microscopic lenses, it appears curiously furnished with a rotatory organ, which encompasses the middle of the body.

It is pellucid, cylindrical, of an unequal size, the fore-part (a) truncated and ciliated, and a triangular prominency (e) in the middle of the aperture; the hind-part obtuse, a point on each side of the middle of the body. This is the appearance of this little creature when in motion; but when the water is nearly exhale'd, some further parts of it's structure are rendered visible; besides the rotatory organ in the anterior part, another is now discovered encompassing the middle of the body; the hairs of this are in vehement motion. There are other fascicles of moving hairs to be discovered at the same time. The variegated and quick motion of this apparatus (more particularly if the animalculum is big with young, and moving at the same time within the mother,) fill the mind with amazement.

301. Vor-

301. *Vorticella Stellina.*

Vorticella orbicularis, disco moleculari, periphæria ciliata.
Orbicular vorticella, with a molecular disc, and ciliated periphery.

302. *Vorticella Discina.* Fig. 8, 9, 10, Plate XXVI. A.

Vorticella orbicularis, margine ciliato, subtus convexo-anfata.
Orbicular vorticella, the edge ciliated, with a kind of convex handle on the under side.

303. *Vorticella Scyphina.*

Vorticella craterformis, crystallina, medio sphærule opaca.
Bowl-shaped vorticella, crystalline, an opaque spherule in the middle.

304. *Vorticella Albina.*

Vorticella cylindrica, postice acuminata. Cylindrical vorticella, the hinder-part tapering, and almost brought to a point.

305. *Vorticella Fritillina.*

Vorticella cylindrica vacua, apice truncata, ciliis prælongis.
Empty cylindrical vorticella, the apex truncated.

306. Vor-

306. *Vorticella Truncatella*.

Vorticella cylindrica, differta, apice truncata, ciliis breviusculis. Cylindrical vorticella, stuffed or filled, the apex truncated, with very short cilia.

It is of the number of the larger animalcula, the body is crystalline, and replete with black molecules, it's skin is perfectly smooth and colourless, it's hinder extremity is rounded, the anterior is truncated; there is a large opening visible at this extremity, which serves as a mouth; this is thickly ciliated.

307. *Vorticella Limacina*. Fig. 60, Plate XXVI.

Vorticella cylindrica, truncata, ciliis bigeminis. Cylindrical truncated vorticella, with two pair of cilia.

308. *Vorticella Fraxinina*.

Vorticella gregaria, cylindracea, oblique truncata, ciliis bigeminis, apice margine fissa. Gregarious cylindrical vorticella, obliquely truncated, with two pair of cilia, and a fissure or notch at the upper edge.

The greater part of the body is cylindrical, the hinder-part is rather tapering, and filled with opaque molecules; towards the upper end it is transparent; within the edge, at top, are two small tubercles, from each side of which a pair of small hairs proceed.

309. *Vorticella Cratægaria*.

See page 437 of this work.

310. *Vorticella Hamata*. Fig. 40, Plate XXVI.

Vorticella bursæformis, margine aperturæ aculeis rigidis. Purse-formed vorticella, the edge of it's aperture or mouth set with rigid points.

It is not ciliated, nor have any-hairs as yet been discovered about it; the body is granulated; the fore-part broad and truncated, the hinder-part obtuse, and capable of being contracted or extended. a the rigid points.

311. *Vorticella Crateriformis*. Fig. 41, Plate XXVI.

Vorticella subquadrata, ciliorum fasciculis etiam postice. This vorticella is rather of a square figure, and has fascicles of cilia even at the hinder-part.

Lively, pellucid, round, longer than it is broad, approaching somewhat to a square, with convex sides; the head is situated at the large end, the skin is smooth, some traces of intestines are with difficulty discovered; at the larger end there is a considerable opening, surrounded by hair; the filaments composing this are in continual motion.

Two of these are sometimes seen conjoined together, as at Fig. 41, and full of small spherules; at this time they may without care be taken for fresh animalcula; they draw each other alternately different ways; in this state the surface is smooth and the hairs invifible. e moveable cilia.

312. *Vorticella Canaliculata.*

Vorticella dilatata, pellucida, latere incifo. Dilated, pellucid, with an incision on the fide.

To the naked eye it appears as fo many white points adhering to the fides of the glafs; when magnified, the anterior part is narrower than the hind-one; in the fide a kind of incision may be perceived, and the hind-part is a little notched towards the middle; it is furnished with a rotatory organ, by which it excites a continual whirling in the water.

313. *Vorticella Verfatilis.*

Vorticella elongata fpiculiformis, mox urceolaris. Long fpear-formed vorticella, but which often changes it's fhape into a pitcher-like form.

A pellucid gelatinous animalculum, of a greenifh colour, furnished with fmall radii, particularly about the circumference, whence it may be confidered as a minute water hedge-hog.

314. Vorticellā Ampulla. Fig. 4 and 5, Plate XXVI. A.

Vorticella folliculo ampulaceo, pellucido, capite bilobo. This vorticella is contained in a pellucid bottle-shaped bag, the head of it is divided into two lobes.

Little more need be said to enable the reader to know this animalculum, if he should meet with it, than to observe that the bag is much in the shape of the common water-bottle; that the animalculum is sometimes to be observed at the bottom of it, sometimes nearly filling it.

315. Vorticella Folliculata.

Vorticella oblonga, folliculo cylindraceo hyalino. Oblong vorticella, in a bright cylindrical bag.

This animalculum is gelatinous and cylindrical; when at it's greatest extension, the base appears attenuated, and the apex truncated.

316. Vorticella Larva.

Vorticella cylindrica, apertura lunata, spinis caudalibus binis. Cylindrical vorticella, the aperture somewhat in the shape of a crescent, two small thorny points projecting from the hinder-part.

The head, the trunk, and the tail may be easily distinguished from each other. It is of a clay-colour, the aperture ciliated;
a glo-

a globular projection may at times be seen to proceed from the aperture.

317. *Vorticella Succolata*. Fig. 42 and 43, Plate XXVI.

Vorticella inverse conica, apertura lunata, trunco postice bidentato, cauda elongata biphylla. This vorticella is in figure an inverted cone, the aperture of a crescent shape, the lower part of the trunk is notched, forming, as it were two teeth, the tail biphyllous.

Each of these parts is surrounded with a loose bright skin, the head is divided from the trunk by a deep incision. a a a small points projecting from the head, b the cilia, c and d the interior parts; l, Fig. 42, the little horn at the bottom of the trunk.

318. *Vorticella Aurita*.

Vorticella cylindrico-ventrosa, apertura mutica, ciliis utrinque rotantibus cauda, articulata biphylla. Cylindrical ventrose vorticella, the aperture destitute of hairs, both sides of it furnished with rotatory cilia, the tail biphyllous.

319. *Vorticella Tremula*.

Vorticella inverse conica, apertura lobata spinulosa, cauda brevi unicuspi. This vorticella is somewhat of a conical shape, the mouth divided into parts which are set with small spines or thorns, a point projects from the tail.

It is a pellucid, crystalline, ventricose animalculum; within it, on one side of the body, there is a large clay-coloured oval mass, adjacent to which there is a pellucid oval substance; the tail is articulated and very short.

320. *Vorticella Senta*.

Vorticella inversa conica, apertura spinosa integra, cauda brevi bicuspi. Somewhat of the shape of a cone, the aperture set with spines, the tail short, and divided into two points.

It has some resemblance to the larger *vorticella rotatoria*, but is easily distinguished from them by its horned spiny aperture, and simple rotatory organ.

The body is muscular, pellucid, folding variously, the fore-part truncated; round the margin of the aperture are rows of hairs, but stiffer hairs or spines are also continually vibrating, with which it draws in all animate and inanimate substances.

321. *Vorticella Lacinulata*. Fig. 45, Plate XXVI.

Vorticella inversa conica, apertura lobata, fetis binis caudalibus. In shape somewhat of an inverted cone, the aperture lobated, the tail small, and furnished with two bristles (d).

The body is muscular, pellucid, cylindrical, the apex about a third part down, drawn into a little neck, the aperture or apex is spread on both sides into a kind of flap or lappet, in the middle is
a lit-

a little lamina, or triangular point; another of these is discovered when the aperture faces the observer, which makes it appear like a small flower. The hind-part, when in motion, is a little bent; it terminates in two minute bristles, which are seen sometimes united, at other times diverging. When the animalculum is swimming, its rotatory organ (a) may be seen; molecular intestines are visible; it moves with velocity in an oblique direction. Is found in pure water.

322. *Vorticella Constricta*.

Vorticella elliptico ventricosa; apertura integra, cauda annulata biphylla. Elliptical ventricose vorticella, the aperture or mouth undivided, the tail annulated and forked.

In this kind, the head, the tail, and the trunk, are fully distinguished. A substance in motion has been perceived, which has been supposed to be the heart; there are two kinds of them, one a pale yellow, the other of a white colour; they move by fixing their tail to the glass upon the stage, and then extending their body as much as possible; they fix the fore-part to the place where they intend to move, and then draw the hinder-part to it, and so on. They sometimes turn round about upon one of the points of their tail, others spring forwards with a jerk. When at rest, they open their mouths very wide, the lips are ciliated, two black globules are discovered in some of them.

323. *Vorticella Togata.*

Vorticella subquadrata, apertura integra, spinis caudalibus binis, plerumque unitis. Square vorticella, the aperture not divided, the tail consisting of two long spines, which are sometimes so united as to appear as one.

The body is convex, of a dark colour, filled with molecules, the middle part pellucid, the hinder-part rather broader than the fore-part, the fore-part ciliated, the tail formed of two very thin pellucid spines, which are somewhat curved, and much longer than the body.

324. *Vorticella Longifeta.*

Vorticella elongata, compressa, fetis caudalibus binis longissimis. Long vorticella, flat, the tail formed of two very long bristles.

The fore-part sinuated, and set with minute cilia; the two bristles which constitute the tail are long, but one is longer than the other.

325. *Vorticella Rotatoria.* Fig. 46, 47, 48, 49, Pl. XXVI.A.

Vorticella cylindrica, pedicello collari, cauda longa quadracuspi. Cylindrical vorticella, with a little foot projecting from the neck, a long tail furnished with four points.

Brachi-

Brachionus corpore conico subæquali. Hill Hist. Anim.

Brachionus corpore conico toruloso. Ditto.

Brachionus. Pallas Zooph. 50.

Joblot Microf. part 2, p. 77, plate 10, fig. 18; and p. 96, plate 5, A B C D E K.

Adams's Micrographia Illustrata, p. 148, plate 40, fig. 255.

Leeuwenhoeck Contin. Arc. Nat. p. 386, f. 1, 2.

Baker's Microf. Exp. p. 95, pl. 6, f. 6, 7, 8.

Baker's Empl. for the Micr. p. 348, 379, pl. 11, f. 1 to 13; and fig. 1, 2, 3, 6, 7, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, of plate XXVI. A, belonging to the work.

Spallanz. Opusc. 2 p. 301, 345, pl. 4, f. 3 to 5.

Rozier Journal Physique, 1775, p. 220.

No person seems to have succeeded so well in the description of the wheel animalculum as Mr. Baker, and all succeeding writers refer us to him for a full account of this little creature. What I shall say upon this animalculum will therefore be taken chiefly from him, though with such additions and alterations as appear to me necessary to render his account complete.

It may be proper to observe, first, that Mr. Muller's wheel animal differs in some respects from that of Mr. Baker's; first, by the rotatory organs on the back, which stretch out like ears; secondly, the two little splendid substances within the body; and thirdly, the two black points near the top of the head, which are probably the creature's eyes.

This little animal is found in rain water that has stood for some days in leaden gutters, or in the hollows of lead on the tops of houses, or in the slime and sediment left in rain water; they are sometimes to be found also in ditches and amongst duck-weed.

It has been called the wheel animal because it is furnished with a pair of instruments, which in figure and motion resemble wheels. It appears only as a living creature when in water, and yet it may be kept for many months out of water, and in a state as dry as dust, without losing the principle of life. When dry, it is of a globular form, about the size of a grain of sand, and without any apparent signs of life. If it be put into the water, in the space of half an hour a languid motion begins, the globule turns itself about, lengthens itself by slow degrees, becomes very lively, and in a little time protrudes its wheels, and swims about in search of food; or else, fixing itself by its tail, brings the food to it by the motion induced on the water by its rotatory organs.

If the water that is found standing in gutters of lead, or the sediment it has left behind, has any thing of a red colour, you may be almost sure of finding these animalcula therein. In summer, when all the water is dried away, if the dust appears red, or of a dark brown, and is put into water, you will seldom fail to discover,

discover, by means of the microscope, a great number of minute reddish globules, which are the animalcula themselves. It is most proper to observe them first with the third or fourth magnifiers, and then to use those which are deeper.

This little creature has some likeness to a caterpillar; its motion from place to place is performed like many of those insects, by first fixing the tail to some substance, then extending the whole body, and fixing the head, then drawing the tail to it; by these alternate actions it moves with some degree of swiftness.

It very often changes its appearance, and assumes a different form; for the snout being drawn inwards, the fore-part becomes clubbed, and immediately dividing, exhibits to our view two circular instruments, set with minute hairs, that move very briskly, sometimes in a rotatory manner, sometimes in a kind of trembling, or vibratory mode. An aperture, or mouth, is also perceived between the two semicircles; the animal may often be seen swimming about in pursuit of food while in this state.

The most distinguishing parts of this animalculum are the head, the thorax, and the abdomen. The form and structure of the head is wonderful, differing from any other creature hitherto described; the sudden change of the head from one form to another is equally surprising and singular; for from being of a very taper form, it becomes on a sudden as broad as any part of the insect, and protrudes an amazing piece of machinery, formed to procure its food.

The circular bodies which project from them have much the resemblance of wheels, and seem to turn round with considerable velocity, by which means a very rapid current of water is brought from a great distance to the mouth of the little creature; as these wheels are very transparent, except the edge, which is set with fibrillæ, (as cogs to a wheel) it is difficult to determine how they are turned about, or what is their real figure, whether they are flat, concave, or conical; be this as it may, they are protruded from a couple of tubular cases, in which they can be again retracted, at the will and pleasure of the animal. They do not always turn the same way, nor with the same velocity; they will sometimes move in contrary directions, sometimes both one way. The figure varies, from the degree of their protrusion, and from other circumstances. They appear sometimes like minute oblong squares, rising from the periphery of a circle; at other times they terminate in sharp points, sometimes they are curved, bending the same way like so many hooks; now and then the ends appear clubbed, or in appearance like a number of little mallets.

When the fore-part of this creature is first seen to open or divide, the parts, which when fully protruded resemble wheels, seem only like a couple of semicircles, the edges whereof are set with little spiculæ, having all a nimble and continual vibrating motion upwards and downwards, whereby the water becomes agitated, each wheel being in this case doubled, or like a round piece of paper folded in the middle.

When the wheels are in motion, the head appears very large in proportion to the size of the animal; and though it is then every-where transparent, yet a ring or circle, more particularly
remark-

remarkable for it's brightness, may be perceived about the middle of the forehead; many vessels may be seen to take their origin from this.

The thorax, or breast, is joined to the head by a short annular circle, or neck; the thorax in size is nearly one-sixth part of the whole animalculum. In it we distinctly perceive the heart of the little creature; the heart is placed almost in the middle, the diastole and systole cannot fail to catch the eye of every attentive observer. It is seen very plainly through the back, shutting and opening alternately with great regularity and exactness. It appears to be composed of two semilunar parts, which in the time of contraction approach each other laterally, and form between them a figure somewhat like a horse-shoe, whose upper side is flat, the under one convex. In the diastole these two parts separate; the separation begins exactly in the middle of the lower part next the tail. The alternate motions of the heart are performed with great strength and vigour. In each of the semilunar parts there is a cavity, which closes when they come together, and opens when they separate.

The motion of the heart is communicated to all the other parts of the thorax, and indeed through the whole animal we may perceive contractions and dilatations going on, that are apparently correspondent thereto. It is necessary, however, to remark, that the motion of the heart is sometimes suspended, or at least quite imperceptible for two or three minutes, after which it recommences, and goes on with the same vigour and regularity as before. From the under part of the thorax a small transparent

horn proceeds, which cannot be seen unless the insect turns on it's back or side.

Below the thorax there is an annular circle that joins the thorax to the abdomen. The abdomen is much the largest part of this animal, it contains the stomach and viscera. When this creature is full of food, the bowels are opaque, and of a crimson colour, extending from the thorax quite through the belly and a great part of the tail, and exhibits a fine view of the peristaltic motion, or those gradual contractions and dilatations of the intestines, which propel their contents downwards. There are many ramifications of vessels, both longitudinal and transverse, round the bowels. It can extend the abdomen in length very much, or contract and widen it considerably; so as to become a case for all the rest of the body. The tail goes from a joint at the lower part of the belly to the posterior extremity; it is of a tapering form, and consists generally of three joints; when it is inclined to fix itself to any thing by the tail, it thrusts out four, sometimes six, little hooks from the end thereof; these are placed in pairs, one pair at the very extremity itself, the other two a little way up the sides; the three are seldom seen at the same time. The wheels seem to be the organ that the animal uses to assist it in swimming.

All the actions of this creature seem to imply sagacity and quickness of sensation; at the least touch or motion in the water they instantly draw in their wheels. Mr. Baker conjectures that they have eyes lodged near the wheels, because while they are in the globular or maggot state, their motions are slow and blundering;

ing; but after the wheels are protruded, they are performed with great regularity, swiftness, and steadiness.

Fig. 17, Plate XXVI. A, represents this little animal in what Mr. Baker calls the maggot state; while in this form small spiculæ are seen to dart out near the anterior part; the snout is sometimes more and sometimes less acute than in this delineation. (a) a small horn near the thorax.

Fig. 15 represents it's manner of moving from place to place, while in the maggot state.

Fig. 12 exhibits it, with the two semicircular parts, put out, and in the posture it places itself in when it is preparing to swim about, or going to put it's wheels in motion.

Fig. 1 shews the head at it's full extent, with a couple of small bodies on the top of it, armed with small teeth like those of the ballance-wheel of a watch.

At Fig. 18 the interior parts are more particularly exhibited. (a) the circle from which many vessels originate; (b) the thorax, or breast, joined to the head by the neck (c.) The part which is supposed to be the heart is plainly seen at (d.) The abdomen (f) is separated from the breast by a ring (e). (g) the tail.

Fig. 19 is the wheel animal, not full extended, but yet working it's wheels about.

Fig.

Fig. 20 shews it with it's side towards the eye; one of the wheels in this position appears to lie considerably below the other.

Fig. 6 and 16 represent two of these creatures in the postures they are often seen in when the wheels are not out, but the fibrillæ are vibrating quickly.

Fig. 2, it is seen with the body nearly drawn into the abdomen; at Fig. 21 it is still further drawn in; at Fig. 22 as it appears just as the tail is drawn in; at Fig. 23 in a globular form, but still adhering by the tail.

Sometimes, when in the maggot form, it rolls it's head and tail together, without drawing them into it's body; it is represented in this plate at Fig. 14.

Mr. Baker has also described three other species, one of which, that differs only from the preceding in having a very long tail, is represented at Fig. 7, Plate XXVI. A.

Fig. 11 is another kind, with crustaceous spiculæ at the forepart; within this, at c, an opaque oval body may be seen, which has been taken for an egg.

Fig. 3 is another kind; it has two projecting points from the tail, and the head furnished with a number of fibrillæ.

Fig.







Fig. 13 represents another species, described by Spallanzani.

Fig. 46, 47, 48, 49, Plate XXVI. represent the wheel animals, seen and delineated by Mr. Müller. a the head, b the eyes, c a small horn, d the rotatory organ, e the tail, f the points of the tail.

326. *Vorticella Furcata.*

Vorticella cylindrica, apertura integra, cauda longiuscula bifida. Cylindrical vorticella, the aperture undivided, the tail rather long, and divided into two parts.

A cylindric body, with a rotatory organ, or row of hairs, at the apex; the tail divided into two parts, a little turning inwards. When at rest, it joins the segments of the tail; but when in motion, it separates them. Generally found in common water.

327. *Vorticella Catullus.* Fig. 50, Plate XXVI.

Vorticella cylindracea, apertura mutica, cauda per brevi, reflexa, bicuspi. Cylindrical vorticella, the aperture plain, the tail short, bent back, and divided into two points.

It is a little thick animalculum, muscular, folding itself up, of an equal breadth throughout, the body disfigured by longitudinal folds, winding variously; the anterior part, or head, connected to the body by a little neck, it occasionally manifests a very minute rotatory organ. The tail (e) is short, terminating in two

very small bristles (d), which it moves and hides at pleasure; the intestines ill-defined. It's motion is rotatory, but in various directions. Is found commonly in marshy waters.

328. *Vorticella Canicula.*

Vorticella cylindracea, apertura mutica, cauda brevi, articulata, bicuspi. Cylindrical vorticella, the aperture plain, the tail short, articulated, and dividing into two pointed parts.

329. *Vorticella Felis.*

Vorticella caudata, cylindracea, mutica, cauda spinis duabus longis terminata. With a tail, cylindrical, beardless, the tail terminating in two long spines.

The body is large, the apex of an equal thickness, obtuse, with rotatory filaments; the tail acute, with two pellucid spines, about one-third of the body in length, separating from and then approaching each other alternately.

330. *Vorticella Stentorea.*

See page 429 of this work.

331. *Vorticella Socialis.*

See page 432 of this work.

332. *Vor-*

332. *Vorticella Flosculosa*. Fig. 51 and 52, Plate XXVI.

Vorticella caudata aggregata, oblongo-ovata, disco dilatato pellucido. With a tail aggregated, of an oblong oval shape, with a dilated pellucid disc.

To the naked eye it appears as a yellow globule, adhering to the ceratophyllon (a) like a little flower (b), or like a heap of yellow eggs. By the microscope they are discovered to be a congeries of vorticellas, constituting a sphere from a mouldy center. They either singly, or many of them together, extend and contract their little bodies, and by means of the disc excite a vortex in the water.

Sometimes they quit the society, and act singly; they may then be observed more easily, and will be found to consist of three parts, a head, abdomen, and tail. The head is often so drawn back into the abdomen (d), that no vestige of it remains; but it exhibits a broad disc standing out, of a kidney-shape. The abdomen (d) is an oblong, oval, pellucid, replete with obscure intestines, amongst which are one or two remarkable black oval spots (e); the tail is sharp, and as long again as the abdomen, rough and annulated, or altogether smooth.

333. *Vorticella Citrina*. Fig. 53, Plate XXVI.

Vorticella simplex, multiformis, orificio contractili, pedunculo æquali. Simple, many-shaped, with an orifice that it can contract, and equal-sized foot-stalk.

The head is full of molecules, round, and every-where of an equal size; very pellucid, both sides of the orifice are ciliated, and each has a rotatory motion, appearing sometimes without the edge of the mouth, as at a a; sometimes within it. No distinct intestines, or internal motion, perceivable. Its motion is different from most of this genus, but not easily described. c c small feet. It is found in stagnant water.

334. *Vorticella Piriformis.*

Vorticella simplex, obovata, pedicello minimo retractili. Simple, somewhat oval, with a very small retractile foot, or one which it can draw within itself.

335. *Vorticella Tuberosa.*

Vorticella simplex, turbinata, apice bituberculata.

Simple vorticella, the upper part broad, the under part small, with two projecting parts at the anterior end, which are furnished with a number of vibrating fibrillæ, that produce a current of water by their quick motion, and thus collect food for our vorticella. Mr. Baker has delineated it in Fig. 10, 11, 12, Plate XIII. of his *Employment for the Microscope*.

336. *Vor-*

336. *Vorticella Ringens.*

Vorticella simplex, obovata, pedunculo minimo, orificio contractili. Simple, somewhat of an oval shape, a small pedicle, an orifice that it contracts or dilates.

The small head, or rather body, of this little creature is pear-shaped, pellucid, the middle of the aperture convex, both sides ciliated, the pedicle four times shorter than the body; it can contract the orifice to an obtuse point.

337. *Vorticella Inclinars.*

Vorticella simplex, deflexa, pedunculo brevi, capitulo retractili. Simple, bent, with a short pedicle, and small retractile head.

A pellucid pendulous little head, the anterior part truncated, and is occasionally, by contraction, made twice as short as the pedicle; its shape is like that of a tobacco-pipe.

338. *Vorticella Vaginata.*

Vorticella simplex, erecta, ovato-truncata, pedunculo vaginato. Simple vorticella, erect, of the shape of a truncated egg, the pedicle contained in a sheath.

For

For the 339th, 340th, and 341st, the author refers to the Zool. Dan. he terms them *vorticella cyathina*, *vorticella putrina*, *vorticella patellina*.

342. *Vorticella Globularia*,

Vorticella simplex, *sphærica*, *pedunculo retortili*. Simple, spherical, with a twisted pedicle.

The little head is spherical, the aperture of the mouth ciliated, the pedicle four times longer than the body, which it contracts in a spiral form. It is frequent among the cyclope quadricorni.

343. *Vorticella Lunaris*. Fig. 54, Plate XXVI.

Vorticella simplex, *hemisphærica*, *pedunculo retortili*. Simple, hemispherical, with a twisted pedicle.

The small head of this animalculum is crater-form (goblet-shaped), the margin of the orifice protuberant, ciliated on both sides, the hairs undulating, the pedicle eight or ten times the length of the body. As often as the mouth is opened, the pedicle extends itself; when it is shut, this is twisted up spirally, and these motions are often reiterated in a short space. a the head when expanded, b when shut, c the undulated edge, d the cilia erect, e when horizontal, f the pedicle when strait, g when bent.

344. *Vorticella Convallaria*.

See page 445 of these essays.

345. *Vorticella Nutans*.

Vorticella simplex, *turbinata*, *pedunculo retortili*. Simple, with a twisted turbinated pedicle.

The pedicle is simple, and twists itself spirally, is exceeding slender, and has a kind of cap on the head; the margin white and round, and as it were encompassed with a lucid ring; the head diminishes towards the base. It is transparent.

346. *Vorticella Nebulifera*. Fig. 66, Plate XXVI.

Vorticella simplex, *ovata*, *pedunculo reflexili*. Simple, egg-shaped, the pedicle bent back.

The body is narrow at the base, open and truncated at top, the margin as it were surrounded with a ring; but when the aperture is shut, the animalculum is egg-shaped, the intestines may be seen distinctly, the pedicle is simple, fetaceous, considerably longer than the body, and generally much bent back. a the head open, b almost shut, c quite shut, d the stalk when strait, at e it is bent.

347. *Vorticella Annularis.*

Vorticella simplex, truncata, pedunculo apice retortili. Simple, truncated, with a pedicle twisted at the end.

This is visible to the naked eye; the head an inverted cone, convex when the mouth is shut, truncated when it is open, with a protuberant edge, the pedicle is simple, very long, thick, and whiter at the top than elsewhere, formed into a little head, the apex is twisted spirally. This animalculum, when contracted, appears to be annulated.

348. *Vorticella Acinosa.*

See page 440 of this work.

349. *Vorticella Fasciculata.*

Vorticella simplex, viridis, campanulata, margine reflexo, pedunculo retortili. Simple, green, bell-shaped, the margin or edge turned back, the pedicle twisted.

A congealed green mass, which is often swimming about in ditches, is composed of myriads of these animalcula, which are not visible to the eye; when magnified, they appear as a bundle of green flowers. The head is bell-shaped, green, opaque, narrow at bottom, pellucid. It has a rotatory organ, which may sometimes be seen projecting beyond the aperture; the pedicle is twisted and very slender; a little head at the apex.

350. *Vorticella Hians.*

Vorticella simplex, citriformis, pedunculo retortili. This is among the most minute. The head resembles a citron, the apex truncated; the base narrow; a gaping cleft is discovered descending from the apex to one-third of the body.

351. *Vorticella Bellis.*

Vorticella simplex, hemispherica, margine contractili. Simple, hemispherical, with a margin that it can contract at pleasure.

The head (capitulum) scarcely pellucid, the inside quite filled, yellow, resembling much the flower of the daisy; it is ciliated round the margin, and are in great abundance, moving in a rotatory manner.

The foot, or pedicle, is long, slender, and pellucid; it is divided into two parts, with small knobs on the top of each; the base adheres to a bulb, the under part is covered with small scales.

352. *Vorticella Gemella.*

Vorticella simplex, sphaerica, capitulo gemino. Simple, spherical, with a double head.

The pedicle is long, and constantly furnished with two little heads at it's apex; these are bright and clear.

353. *Vorticella Pyraria*.

See page 437 of this work.

354. *Vorticella Anastatica*.

See page 434 of these essays.

355. *Vorticella Digitalis*.

See page 444 of this work.

356. *Vorticella Polypina*. Fig. 61, Plate XXVI.

Vorticella compofita, ovato-truncata, pedunculo reflexili ramofiffimo. Compound vorticella, oval, truncated, with a bending branching stalk.

When viewed with a small magnifier, they appear like fo many little trees; the upper part, or heads, are egg-shaped, the top truncated, the lower part filled with intestines; the branches are thick fet with little knobs. a the trunk, b the branches, c the head when extended, f the small knobs thereon.

357. *Vorticella Racemofa*.

Vorticella compofita, pedunculo rigido, pedicellis ramofiffimis longis. Compound, pedicle rigid, with small branched long feet.

To

To the naked eye it appears like the vorticella socialis, but is distinguished from it by always adhering to the sides of the vessel in which it is placed. On examining it with a magnifier, a long very fine pedicle is perceived sticking to the sides of the vessels, from which proceed an innumerable quantity of crystalline pellucid pearls, which, together with the stalk, are variously agitated in the water. They sometimes move separately, sometimes together, are sometimes drawn down to the root, and in a moment again expanded.

XVII. BRACHIONUS.

Vermis contractilis, testa tectus, ciliis rotatoriis. A worm capable of contracting, covered with a shell, and furnished with rotatory cilia.

358. Brachionus Striatus. Fig. 64 and 65, Plate XXVI.

Brachionus univalvis, testa ovata striata, apice fexdentata, basi integra, cauda nulla. Univalved brachionus, the shell oval and striated, six notches or teeth round the upper edge, the base whole or even, without a tail.

The shell is oblong, pellucid, and capable of alterations in its figure. The apex (a) truncated, with six small teeth on the edge of it, twelve longitudinal streaks down the back, the base obtuse and smooth. The teeth are occasionally either protruded or retracted; on the other side of the shell, towards the tail, there are two little spines or horns (c).

The animalculum is pellucid, crystalline, and muscular, often of a yellow colour; from the apex it now and then puts forth three little bundles of playing hairs, the two lateral ones shorter than the middle one; a forked deglutatory muscle (e) may be perceived, and on the under side, when the apex is drawn in, we discover two rigid points. It is an inhabitant of the sea.

359. *Brachionus Squamula.*

Brachionus univalvis, testâ orbicularis, apice truncata quadridentata, basi integra, cauda nulla. Univalved brachionus, with an orbicular shell, the apex truncated, and having four teeth, the base smooth, no tail.

360. *Brachionus Pala.*

Brachionus univalvis, testâ oblonga excavata, apice quadridentata, basi integra, cauda nulla. Univalved brachionus, with an oblong excavated shell, four long teeth at the apex, the base smooth, no tail. It is of a yellow colour.

361. *Brachionus Bipalium.*

Brachionus univalvis, testâ oblonga inflexa, apice decemdentata, basi integra, cauda spuria. Univalved brachionus, the shell oblong and inflected, ten teeth at the apex, the base smooth, a spurious tail.

362. Bra-

362. *Brachionus Patina*.

Brachionus univalvis, testa orbiculari integra, cauda mutica. Univalved brachionus, with an orbicular shell, the edges regular, and having a long beardless tail.

This animalculum is large, the shell crystalline, nearly circular, without any teeth or incision, though towards the apex it rather falls in, so as to form a smooth notch. This little creature is remarkably bright or splendid; it is affixed to the middle of the shell; it projects from the apex a double glittering organ, the edges of which are ciliated; both these organs are of a conical figure, and stand as it were upon a pellucid substance, which is divided into two lobes; between these lobes and the rotatory instrument there is a silver-coloured crenulated membrane; two small claws may be discovered near the mouth and other organized parts.

363. *Brachionus Clypeatus*.

Brachionus univalvis, testa oblonga, apice emarginata, basi integra, cauda mutica. Univalved brachionus, the shell oblong, the apex notched, the base smooth, the tail naked.

364. *Brachionus Lamellaris*.

Brachionus univalvis, testa producta, apice integra, basi tricorni, cauda bipili. Univalved brachionus, the shell extending
consider-

considerably beyond the body, the base divided into three small horns, at the end of the tail there are two hairs.

365. *Brachionus Patella.*

Brachionus univalvis, testa ovata, apice bidentata, basi emarginata, cauda bifida. *Brachionus* with a univalve oval shell, two teeth at the apex, the base notched, two bristles at the tail.

The shell plain, oval, orbicular, crystalline, the anterior part terminating in two acute points on both sides, though the head of the animal for the most part fills up the intervening space.

The head, the tail, and the trunk are very distinct; the bottom of the trunk is terminated in a semicircle, the fore-part marked with two transversal lines; it occupies the disc of the shell. The intestines are indistinct, the tail is affixed to the trunk; it is short, annulated, flexible, the middle projecting beyond the shell, the apex diverging into two very fine bristles (g); it fastens itself by these, and whirls about with the body erect; the rotatory cilia (c) are with great difficulty perceived. Found in marshy water all the winter.

366. *Brachionus Bractea.*

Brachionus univalvis, testa suborbiculari, apice lunata, basi integra, cauda spina duplici. Univalved brachionus, the shell rather orbicular, the apex lunated, the base smooth, the tail furnished with two spines.

367. *Brachionus Plicatilis*.

Brachionus univalvis, testa oblonga, apice crenulata, basi emarginata. Univalved brachionus, with an oblong shell, the apex hairy, the base notched.

368. *Brachionus Ovalis*.

Brachionus bivalvis, testa depressa, apice emarginata, basi incisa, cauda cirro duplici. Bivalved brachionus, with a flattened shell, the apex notched, a hollow part at the base, the tail formed of two tufts of hair.

369. *Brachionus Tripos*. Fig. 59, Plate XXVI.

Brachionus bivalvis, testa apice mutica, basi tricorni, cauda duplici. Bivalved, the apex of the shell beardless, three horns at the base, double tail.

The body is pellucid, nearly triangular, bivalved, open on the back of the animalculum; from the orifice two little laminæ proceed, that are larger than the rotatory cilia; at the bottom are three or four stiff points *e f a*, and a moveable tail (*g*) between them, divided into two filaments, which the little creature opens and shuts at pleasure; by these it fixes itself to objects. *a* the lateral cilia, *b* two small laminæ, *c* a deglutatory muscle, *e* an opaque mass.

370. Bra-

370. *Brachionus Dentatus.*

Brachionus bivalvis, testâ arcuata, apice et basi utrinque dentata, cauda spina duplici. Bivalved brachionus, with an arched shell, the apex and the base are both toothed, the tail formed of two spines.

371. *Brachionus Mucronatus.*

Brachionus bivalvis, subquadrata, apice et basi utrinque mucronata, cauda spina duplici. Bivalved, somewhat of a square form, the base and apex pointed, the tail consisting of two spines.

372. *Brachionus Uncinatus.* Fig. 55, Plate XXVI.

Brachionus bivalvis, testâ ovali, apice integra, basi mucronata, cauda rugosa bifeta. Bivalved brachionus, with an oval shell, the apex even, the base pointed, two thick bristles for the tail.

This is one of the smallest bivalved animalcula, the apex and anterior part round, the hinder-part strait, terminating in a point, muscular, furnished with a hook on the fore-part, a small rotatory organ, a tail composed of joints, long, and cloven at the end into two bristles. It can open it's shell both at the fore and hind-part. a the shell when close, c the posterior point, d the animalculum, h the tail, i the bristles.

373. Bra-

373. *Brachionus Cirratus*.

Brachionus capularis, testa apice producta, basi curti, bicorni, cauda bifeta. Larger than the preceding, ventricose, somewhat pellucid, the head conical, on both sides of which is a bundle of hairs; it has also a rotatory organ.

374. *Brachionus Passus*.

Brachionus capularis, testa cylindracea, frontis cirris binis pendulis, setae caudali unica. Capular brachionus, in a cylindric shell, two long pendulous locks of hair proceed from the front, the tail consists of a single bristle.

375. *Brachionus Quadratus*.

Brachionus capularis, testa quadrangula, apice bidentata, basi bicorni, cauda nulla. Capular brachionus, in a quadrangular shell, with two small teeth at the apex, two horns proceed from the base, it has no tail.

376. *Brachionus Impressus*.

Brachionus capularis, testa quadrangula, apice integra, basi obtusi emarginata, cauda flexuosa. Capular brachionus, the shell quadrangular, the apex smooth or undivided, the base obtuse, the margin notched, the tail flexuous or bending.

377. *Brachionus Urceolaris*.

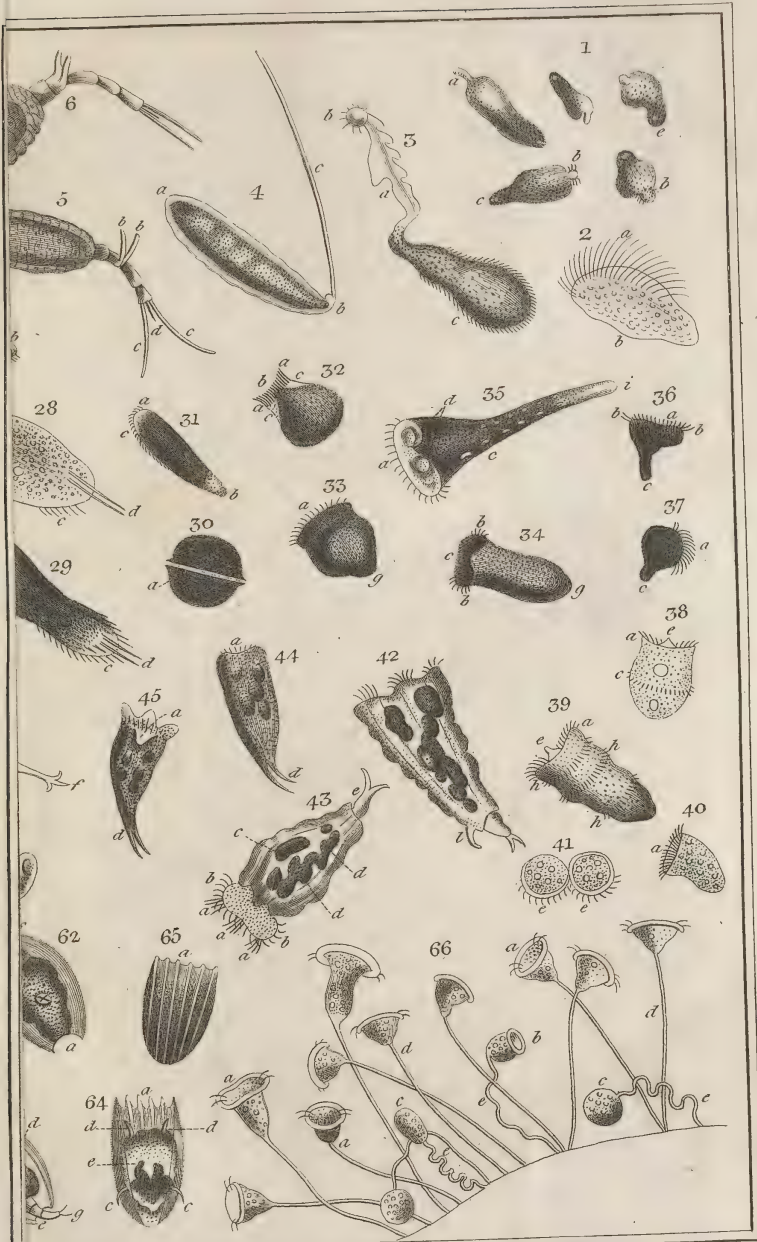
Fig. 56 and 57, Plate XXVI. and Fig. 36, 37, 38, Plate XXII.

For a full description of this see page 448.

378. *Brachionus Bakeri*. Fig. 58, Plate XXVI.

Brachionus capfularis, testâ ventricosâ, apice quadridentatâ, basi bicorni, cauda longa, bicuspi. Capfular brachionus, the shell ventricose, four teeth at the apex, two horns at the base, the tail long, and terminating in two short points.

This differs considerably from the foregoing in the shape of the shell, from each side of which there is a curved projection inclining towards the tail, nearly of the same length with it, and terminating in a point. The upper part also of the shell is of a different form, having in general four longer spiculæ, and two shorter ones. From the head two arms, or branches, are frequently extended; the circular end of each is furnished with a border of little hairs, which one while move in a vibratory manner, at another time they have a rotatory motion. The eggs are either affixed to the tail, or the curved part of the shell; they have from one to five hanging from them. Mr. Muller has further discovered two small feelers, and a kind of tongue to this little creature. a the rotatory organ, b the tongue, c the feelers, d a ciliated part on the side of the shell.



The act directors, May 20, 1787.

J. Lodge sc.



T. Milne del.

London. Printed for & Published by George Adams, No 60, Fleet Street, as the act directs. May 20. 1787.

J. Lodge sc.

379. *Brachionus Patulus*.

Brachionus capfularis, testa ventrosa, apice octodentata, basi lunata quadricorni, cauda brevi bicuspi. Capfular brachionus, the shell ventrose, eight teeth at the apex, the base lunated or hollowed into the form of a crescent, and furnished with four horns, the tail short, with two small points at the end.



C H A P. IX.

ON THE ORGANIZATION OR CONSTRUCTION OF TIMBER,
AS VIEWED BY THE MICROSCOPE.

THE subject of the following chapter opens an extensive field of observation to the naturalist, in which the labour of a life may be well employed: it is a branch where the observer will find the microscope of continual use, and without which he will scarce be able to form any just idea of the organization of trees and plants, of the variations in the disposition, the number, nature, and offices of the several parts thereof.

Malpighi, Grew, Duhamel, Hill, Bonnet, and De Saussure, are almost the only writers who have treated on this subject; and if we consider the imperfection of the instruments used by some in those anatomical researches, and the little attention paid by the rest to the advantages their favorite pursuits might have derived from the use of the microscope and the dissecting knife, we have rather more to wonder at what has been done, than at what remains to be performed. One reason that our knowledge of the subject of this chapter is so circumscribed, is the general inatten-

tion to the structure of plants; to this, among other causes, we may also ascribe the instability and fluctuation of the different theories on the principles of vegetation. We are, however, so little acquainted with the steps which Providence takes to lead intellectual, but free agents, to the knowledge of truth, and the various difficulties, errors, and prejudices that must be removed before it can shine in it's native colours, that it is our duty to encourage every humble effort towards the advancement of science, that thus we may co-operate with our Creator and Redeemer in promoting that vast plan to which all things are now converging, the bringing all his creatures to a state of truth, goodness, and consequent happiness, an end worthy of the best and wisest of beings.*

As Dr. Hill is the first writer who has treated this part of natural history in an orderly and scientific manner, I shall use the names he has adopted for characterizing the different parts of trees, &c. which are, 1. the rind; 2. the bark; 3. the blea; 4. the wood; 5. the corona or circle of propagation; 6. the pith. These are placed immediately within or under one another; they are the essential parts upon which the strength of the tree depends: in, among, and between these, the various vessels are placed, which nourish the whole, and maintain and carry on the vegetation of the tree, and from which it obtains it's peculiar qualities and virtues. These vessels are of five kinds.

JUICE

* See the Bishop of Exeter's Sermon before the Society for the Propagation of the Gospel.

JUICE VESSELS.

1. The exterior vessels, placed between the rind and the bark.
2. The interior, in the substance of the bark.
3. The intimate, in the substance of the blea.
4. The sap vessels, in the substance of the wood.
5. The coronal, in the corona.

More accurate instruments, or a more minute investigation of the parts, may probably discover new vessels, in a system which appears to be entirely vascular, and bring us more thoroughly acquainted with the nature of vegetation.

OF THE RIND.

The exterior covering of all trees is a thin, dry, parched substance, which has been compared by many writers to the skin of animals, and called by names analogous thereto; thus it is called the epidermis by Duhamel, the skin by Grew, the rind by Hill.

When a tree is full of sap, this membrane may be easily detached from the part it covers; it may be separated from green branches which are not in sap, by boiling them in water; large pieces of it may also be obtained from rotten branches; the rind of the leaves of many trees is detached with singular dexterity from the other parts, by some of the mining caterpillars; artificial methods for effecting this purpose have been described in page 159 of this work. Though the rind may at first sight be thought to be of little use, it will be found to be a principal organ in the process

process of vegetation; the part which covers the root has the most important offices assigned to it.

Many are of opinion that the rind is formed of dried vesicula; and Malpighi says, that we may see in the vascular texture of the bark of the cherry and plumb trees an arrangement of the parts proper to form the rind, and this arrangement is occasioned by the endeavour of the vascular part to extend itself to the circumference, and the resistance it meets with from the rind; and that hence the vessels are flattened, and assume a membranaceous form.

The rind is a general covering to the young trunks of trees, to the branches, the roots, the leaves, the fruit, the flowers, &c. Upon the trunks of large trees some pieces only of the rind are to be found, having probably been broke by the increased size of the tree. The rind of some species of trees will bear being stretched much further than those of others, and remain for a considerable time uniformly spread over the bark. Duhamel asserts, that the rind of vigorous healthy trees remains longer whole than on those that are more languid, notwithstanding that the growth of the last is slower, and therefore makes less efforts against the rind. This circumstance is much in favour of the distinct organization of the rind, and against the opinion of those who only suppose it to consist of dried bladders.

Thin as the rind is, it is formed of many coats, adhering closely to each other, which in some species may be separated with ease, in others with difficulty. Duhamel says, that he has divided the
rind:

rind of the birch into six distinct coats, and that he had no doubt but what the division might have been carried much further. Dr. Hill says, that unless some of these coats are obtained in a state of separation from the rest, the true construction of the rind cannot be discovered, for the connection and form of the parts is lost by the confusion in which they appear while they lie one upon another.

The following experiments may throw a little light upon this obscure subject.* All the rind was taken from the trunk of a cherry tree, and the tree thus skinned, exposed to the air, a part of the bark which was next to the rind dried up and exfoliated; the part next to this did the same; after two or three exfoliations, a farinaceous substance covered the superficies of the trunk, soon after which a new rind appeared. Some pieces of rind were taken from a few young branches, and the wounds were covered with a cloth that had been soaked in wax and turpentine; on these the rind appeared in a very little time, without any apparent exfoliation. From some other branches, not only the rind, but a part of the bark, was also taken away, and the wounds covered as before; a slight exfoliation was observed here, which was soon followed with a new rind. The bark was taken entirely off from a vigorous cherry-tree, while it was in full sap, so that the wood appeared the whole extent of the trunk. This was protected from the rays of the sun, and from the air. A new bark and rind formed themselves upon the trunk, but they did not originate from the bark that was left on the branches and the root, but extended from different spots, which were first formed at considerable

* Duhamel *Physique des Arbres*, tom. I, p. 12.

siderable distances from each other. After a lapse of fifteen years, this new rind did not appear like the natural rind of the cherry-tree. From these experiments we learn, that the rind regenerates more readily in some cases than in others, and that it preserves and prevents in a degree the bark from becoming dry too soon, and in consequence thereof exfoliating.

Aided by the microscope, a number of luminous points may be discovered in the rind; * these are so many minute holes for other purposes of transpiration. In the cane these holes are visible to the naked eye. A few oval holes may also be perceived in it; these are, however, no more than a separation of the parts, occasioned by the extension of the *vasa interiora*.

Dr. Grew supposed the rind to be formed of small vesicles, or bladders, clustered together, and intermixed with lignous fibres or vessels, which run through the length of the rind; these are conjoined by other transverse ones, but that as the rind dries, the bladders or blebs shrink up and disappear. This account does not differ much from that of Dr. Hill, who says, that the rind is formed of a series of longitudinal vessels, and a filmy substance between them, which, when viewed in a transverse section, form small circles, the sides of which are supported and made up of these longitudinal fibres; that the transverse vessels are only a deception, occasioned by the spaces between part and part of the film. The mode of obtaining an accurate view of the organization of this part, by conveying coloured liquors into the several vessels thereof, has been already described in page 162 of these

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essays;

* Duhamel *Physique des Arbres*, vol. 1, p. 9.

effays; by this means, together with the microscope, we find that the vessels are every-where pierced with small dots, or openings; of the use of these the following conjectures have been formed.*

The root, which is equal in surface to a third part of the tree above ground, is covered with a pierced rind. The cold of winter contracts the whole of this, the parts are drawn closer together, and the mouths of these innumerable vessels are shut, or nearly so, by this contraction; a very little of the half congealed moisture of the ground gets into them, but this suffices for the service of the tree, when there is little heat to cause any perspiration, and at a time when in the deciduous trees, the very organs of the greatest perspiration, the leaves, do not exist.

The warmth of spring arrives, the fluids of the earth grow thinner, every part of the root expands; this opens the mouths of the vessels, and the torrent of nutrition rushes in. By this means, every coat of the rind, and the interstitial spaces thereof, are rendered supple, and may be easily separated from the under coverings.

In roots the colour of the rind varies very much, being white in some, brown in others, &c. Every root, according to Grew, after it has arrived at a certain age, has a double skin, the one coeval with the other parts, and exists in the seed: a ring is afterwards sent off from the bark, which forms the second skin; thus in the root of dandelion, towards the end of May, the original or outer skin appears shrivelled, and is easily separated from the new one,

* Hill's Construction of Timber, &c. p. 37.

one, which is fresher, and adheres more firmly to the bark. Perennial plants are supplied in this manner with a new skin every year; the outer one always falls off in the autumn and winter, and a new one is formed from the bark in the succeeding spring.

OF THE VESSELS WHICH ARE CONTAINED BETWEEN THE
RIND AND THE BARK.

These are called by Duhamel the cellular coat, (*enveloppe cellulaire*) by Hill the exterior vessels, and the *vasa propria exteriora*.

It has been already observed, that in trees the juice vessels, or *vasa propria*, do not form those constituent parts of the wood of which the timber consists, but that it is from the nature of these recipient vessels that it derives its virtues, qualities, and specific properties.* A tree may grow, live, and give shade without them; but on those its peculiar character and decided virtues depend; these are greatest where the *vasa propria* are largest or most numerous, and where we do not find these, we scarce find any thing that will affect the taste or the smell. There are different ranges of these vessels between the several parts, each of which has its allotted place, its peculiar form, its different structure, and its separate use. Many trees have them in all their parts, others only in some of them, while others do not exhibit any.

On taking off the rind, we find a substance of a deep green colour, succulent and herbaceous, formed of a prodigious number

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of

* Hill's Construction of Timber, p. 73.

of filaments, interwoven together in various directions; it is more abundant in some trees than in others, particularly in the elder, and more succulent in summer than in winter; it is then also less adherent to the rind. Dr. Hill thinks the best time of separating the rind, in order to view this part, is in a living branch, at the time of it's swelling for the spring, or for the mid-summer shoot, but much easier by the means of maceration.*

When the rind is perfectly separated, it leaves the *vasa propria* of this class behind it; they scarce adhere to the inner bark, and but little to the rind; they are disposed in packets, and do not run strait down the branch, but interweaving with each other form a kind of net. These packets may be separated easily from the bark; when a thin transverse section of one of them is examined, it is found to be composed of twelve or fifteen distinct vessels, with hard rinds. Dr. Hill says, that with a great deal of patience, a vast number of objects, and a good microscope, we may see by what means these vessels adhere to the bark; for we shall find upon the sides small oval depressions which fit thereto, and that are probably a kind of glands, that separate from the general store of sap with which the bark is filled; the juices peculiar to these vessels.

OF THE BARK.

The bark lies next within the rind, and differs but little from it in construction, though it holds a more important office in the scale of vegetation, the growth and qualities of the tree being in
a great

* Hill's Construction of Timber, p. 75.

a great measure connected with it. It is, therefore, found to differ considerably in substance, quantity, and quality, in various kinds.

It is originally the outer membrane, covering the lobes of the seed. Even there, as in the branch of a tree, it appears in form of a kind of sponge, or like a crust of bread, composed of flattened bladders.

It's sponge-like nature may be further inferred from the contraction of it's pores when dry, and the ease with which they dilate when in water. Grew has called it a most curious and exquisitely fine-wrought sponge. In the course of it's growth, the outer ranges of these bladders drying, it becomes what we call the rind; for the rind was once bark, and has only suffered a slight change in separating from it.

By the bark the tree is fed with a continual supply of moisture, protected from external injuries, and defended from the excesses of heat and cold; for these purposes it is variously disposed in different trees. In the hardy and slow growing, as the oak, it is thin; in the quick growing, as willow, poplar, and the like, it is thick. And what is more particularly to be attended to is, that in some it's inner verge is radiated. There are some trees, and a great many herbaceous plants, in which this part is continued inward, in form of rays, through the blea into the wood, forming as it were so many wedges, that split as it were the substance of both those parts,* a circumstance which accounts for the vegetation of some particular trees, which are known to live when deprived

* Hill's Construction of Timber, p. 118. Ibid. p. 120.

prived of the bark; because they have rays of the same substance within, which answer the purpose, and this in a degree answering to the nature of their life.

The bark appears to be formed, first, of longitudinal fibres, which Duhamel considers as so many lymphatic vessels; secondly, by a kind of a filmy cellular tissue, which have been considered as a kind of bladders by some, or as parenchymous by others; thirdly, of the *vasa propria interiora*, or interior juice vessels.

The longitudinal fibres are disposed in strata, which lie one over the other. In that stratum which is next the rind, or rather the cellular coat, we perceive a net of longitudinal fibres, the meshes of which are large and easily distinguished, particularly when the cellular tissue that fills up the interstices is removed. To do this, the branches should be macerated for a considerable time; some require to be kept in this state for years. It will then be easy to separate first the rind, then the cellular coating, and afterwards this pulpy matter. It may sometimes be easily removed after the branches have been boiled.

The most exterior stratum, when examined by the naked eye, seems to be formed of simple fibres, which graft, folder, or anastomose one with the other; but when examined by a microscope, each of these fibres will be found to be a bundle of filaments, which may be easily separated from each other.

Grew says, that each filament, like the nerves in animals, consists of twenty or thirty small contiguous tubes, which run uniformly from the extremity of the root, without sending off any branches,

branches, or suffering any change in their size and shape. Hence the bark may be tore or divided lengthways, with greater ease than in an horizontal direction; when macerated, they are capable of a very great degree of subdivision.

The filaments of a cortical vessel are to be looked on (agreeable to what we have already observed) as so many little bundles placed near together, and at first growing parallel to each other; but soon quitting this direction, the filaments of one fascicle parting from that to which they originally belonged, and inclining more or less obliquely towards another, sometimes uniting with it, at others bending backwards, and uniting again with that from which it proceeded, or with some one that it meets with. In this manner new fascicles are often formed, while other parcels are increased or diminished by the additions of new filaments; by this means, a kind of irregular net is formed, and the fibres proceed in a serpentine line from the top to the bottom of the tree.

The thickness of the bark is entirely formed of strata of these longitudinal fibres, which lie one over the other; each of these strata is similar to the exterior one, only the meshes are smaller, and the fibres finer, in proportion as they are more interior, in so much that at last the meshes are almost annihilated, and the fibres seem to lie quite parallel to each other.

There are some trees, however, where the meshes are not visible, and in which the fibres lie quite in a strait direction. There are many other circumstances in which they vary in different trees; in some the meshes of each stratum correspond with each other,

-diminishing gradually in size as they are more interior, and forming as it were so many conical cells.

We may, I think, conclude from what has been said, that the bark is composed of several thin membranes, which extend over the whole exterior surface of the tree. The most exterior membrane is the rind; under this is what Duhamel calls the cellular coat; next to this the cortical stratum or true bark of the tree, which is formed of lymphatic vessels ranged more or less in a reticular form, and of the *vasa propria interiora*. The meshes are so constituted as to form large cavities next the rind, and small ones near the wood. These cavities are filled with a parenchymous substance or the cellular tissue, which being continued from the wood to the rind, joins and unites the cortical stratum, and afterwards spreading on the outside thereof, forms what has been termed the cellular coat.

OF THE CELLULAR TISSUE.

We now proceed to give some account of the substance which fills up the vacant spaces that are left between the longitudinal fibres. It is called by Grew the parenchyma or pulp, by Malpighi, the vesicular tissue or web; both of them consider it as formed of small bladders or reticules, that are in contact with each other, lying in an horizontal position, or at right angles to the longitudinal fibres: they do not suppose them to be all of the same size, or even of the same figure: Grew compares it to the froth of beer or eggs. The flesh of fruits consists for the most part of this substance, very much filled with juice, though with considerable difference in its organization. Be this as it may,
the

the nature of this substance, its form and structure, are at present but very little known. It is floccose, and varies in colour in different species.

OF THE VASA PROPRIA INTERIORA.

Besides the lymphatic vessels and the cellular substance, we find the juice vessels, or vasa propria, in the bark. In those trees which are famous for medicinal virtues, they are usually very large; they carry the milky juices of the sumach, and in them is lodged the finest and highest-flavoured turpentine in all the kinds of pine. Dr. Hill thinks that a tree of that genus exhibits them best, and the more, as the turpentine which fills them may be perfectly dissolved in spirit of wine. The *pinus orientalis* is the species in which these vessels are most distinctly seen.

OF THE BLEA.

This is that part of the tree which is forming into wood, and therefore lies between it and the bark, and may be separated from them by maceration.

A longitudinal piece of the blea, when examined by the microscope, exhibits a number of vessels running parallel to each other, the interstitial spaces being filled with a floccose, white, formless substance, of which Dr. Hill suspects even the vessels themselves to be formed. Innumerable small openings, or mouths, may be discovered in these vessels, suited to imbibe the moisture which is so essential to the life and health of plants. These mouths cannot be well discerned, except when they are

opened by the season of the year, either before the first leaves of spring, or in the midsummer shooting time; though a small quantity of moisture will keep them open at that time, yet no quantity would be sufficient at an improper season.*

The blea is a zone more or less perfect, which lies under the bark, and covers or surrounds the wood, and is principally distinguished from it by being less dense. In some species the difference between the blea and the wood is very remarkable, in others it is less so.

The ancient botanists, struck with the difference they observed between the wood and the blea, compared this substance to the fat in animals. Malpighi, Grew, and Duhamel consider it as the wood not yet arrived to a state of perfection. It is organized in a manner similar to the wood, and possessing the same vessels, disposed nearly in the same manner. The juice vessels of this part may be separated from it by maceration; Dr. Hill says, that in this state they appear perfect cylinders, with thick white coats, the surface perfectly uniform.

OF THE WOOD.

When the bark and the blea is taken away, we come to the wood, which is a solid substance, on which the strength of the tree depends, and which has been considered by naturalists as being to the tree what bones are to the animal. The wood, in a general view, may be considered as formed of strata, which are inclosed one within the other; these strata consist of lignous fibres

* Hill's Construction of Timber.

fibres or lymphatic vessels, the cellular web or tissue, vasa propria, and what have been called the air vessels. It is more difficult to investigate the construction of the wood than that of the other parts, because the texture is in general much harder, and therefore not so easily separated, requiring very long macerations, and many subjects, before one may be found fit for examination.

If we examine a transverse section of almost any kind of wood, we shall perceive these strata very clearly and sensibly distinguished from one another. It has been generally supposed, that each of these is the product of one year's growth; though if we cut the same wood obliquely, we shall perceive that each of these strata is compounded of smaller ones, which are, therefore, not so easy to discover as the larger. By macerating rotten pieces of trees, the wood may be divided into an immense number of leaves, or strata, thinner than the finest paper.

If the foregoing strata are examined in their detached state by the microscope, we shall find them to be composed of longitudinal fibres; some pieces of rotten wood, after maceration, will divide of themselves into very fine longitudinal fibres; the existence of these is further proved by the facility with which wood may be split in the direction of these fibres. From hence we may collect, that the lignous strata are formed of small fibres or vessels, collected together in fascicles, like the bark: in some trees they are parallel to each other, in others they are disposed more obliquely, crossing and forming an irregular kind of network. There is great probability that this reticular disposition exists in all trees, though it may be difficult to discover it in many

on account of the fineness of the meshes, the hardness of the wood, and the sameness of colour in the constituent fibres.

We are here only speaking of the lymphatic vessels or lignous fibres of the wood, which exist in it as well as in the bark, though in different states; for the lignous fibres are always harder and less flexible than the cortical ones. Malpighi thinks they differ in another particular, namely, that a juice or fluid issues from the cortical, while none is found in those of the wood. In this it would appear from the observations of Duhamel, that he was mistaken.

A transverse section of wood generally appears formed of a number of rays proceeding from the corona to the bark, which are intersected at different distances by concentric circles, interspersed with vessels of varying magnitude: the variations in this structure afford much pleasure to the curious observer, and throw considerable light upon the nature and properties of timber; for it is by means of a variety of strainers that different juices are prepared from the same mass. Matter, considered as matter, has no share in the qualities of bodies. It is from the arrangement of it, or the recipient forms given to it, that we have so many different substances. According to the modifications that these receive, we shall find the same light, air, water, and earth, manifesting themselves in one by a deadly poison, and in another by the most salubrious food. A lemon ingrafted upon an orange stock, is capable of changing the sap of the orange into its own nature, by a different arrangement of the nutritive juices. One mass of earth will give life and vigour to the bitter aloe, to the sweet cane, the
cool

cool house-leek, and the fiery mustard, the nourishing grain, and the deadly night-shade.

The wood may be considered as composed of two parts, lignous and parenchymous. We have already treated of the former; the latter is that which is disposed into rays running as it were between the lignous fibres, and interweaving with them; it originates either with the pith or corona. There is a very great diversity in these radial insertions, in some trees there are very few, while they abound in others; in some they are very fine, in others very thick. In texture they seem similar to the blebs of the bark, only that here they are so crowded and stretched out as to appear like parallel threads, something similar to a net when drawn tight.

OF THE CORONA.

Dr. Hill gives this name to that circle which surrounds the pith, and separates it from the wood; although in his opinion it differs greatly from both, and in its composition has no resemblance to either. It is, according to him, the most important part in the whole vegetable fabric, by which the propagation and increase of the branches, buds, and shoots, is carried on.*

It has been usual to suppose the pith of vegetables to be the part in which these wonderful sources of increase resides, but this is not the case; and he asserts, that so far from being prior to the other parts, it is in reality posterior to some of them.

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* Hill on the Construction of Timber, p. 55.

The corona is not so uniform as the other parts, nor is it constituted exactly similar in all trees. It is placed between the pith and wood in all vegetables, forming a ring, whose outline is more or less regulated. The general circle is cellular, composed of blebs and vessels, like the bark and the rind, and is perfectly similar to them, only that at different distances oblong clusters of different vessels are placed amongst it. These clusters are usually eight or ten in number, and give origin to the angles of the corona. They are not uniform, or of one kind of vessels, as in the bark, but each has two distinct sorts, the exterior one answering to the blea, and the interior to the wood of trees; and within each of these are disposed vessels not unlike those in the blea and wood, though often larger than they are found in those parts.

Thus each cluster is composed of all the essential parts of the succeeding branch, and the intermediate parts of the circle are absolutely bark and rind; they are ready to follow and clothe the cluster when it goes off in the form of a shoot, because it will then need their covering and defence, though, in its present inclosed state, it does not. It is from this construction that a tree is ready at all times, and in all parts, to shoot out branches, and every branch in the same manner to send out others; for the whole trunk, and the branch in all its length, have this course of essential vessels ready to be protruded out, and the proper and natural integuments as ready to cover them. In some trees these parts are more evident, in others more obscurely arranged. Dr. Hill says, the bocconia, or parrot-wood of the West-Indies, and the greater celandine, are proper subjects for opening this great mystery

mystery of nature. On the corona and it's clusters depend that property of vegetables, that they can be produced entire from every piece. These clusters follow the course of the other portions of the tree; they are, therefore, every-where; they are always capable of growing, and their growth, even in a cutting of the smallest twig, cannot produce a leaf or any other part of a vegetable alone, but must afford the whole, for they are complete bodies, and the whole is there waiting only for the opportunities of extension. For the knowledge we have of this part we are altogether indebted to Dr. Hill. It remains for future observers to confirm or disprove his observations.

OF THE PITH.

The pith is found in the center of every young shoot of a tree; it is large in some, less in others, but present in all. It is placed close within the corona.

It seems to be nothing more than a congeries of the cellular tissue; it is generally found near the center of the tree, inclosed as it were within a tube; in general, the cells of the pith are larger than those of the cellular tissue, with which, according to Duhamel, it communicates. For the rays which extend from the pith to the bark are, in his opinion, produced from it. Thus, though it may differ in name from the parenchymous parts of the bark, and the radial insertions in the wood, yet it is of the same nature and texture, and is continuous with them; so that, according to this idea, the skin, the parenchyma, the insertions, and the

pith, are all one piece of work, filled up in divers manners with the vessels.

The bark and the wood grow thicker every year, while the pith, on the contrary, grows more slender, so that in a branch of one year it is of a larger size than it is in the same branch when two years old, and so on. In very young branches, while in an herbaceous state, the pith forms the greatest part of it's substance; but when the fibres are stronger, the pith becomes less succulent, and surrounded with a tube of wood; when the branch is arrived to a certain age, it is so compressed as to be almost annihilated. In examining different branches that proceed from others in their first state, a small communication between the pith of the one and the other will be found; but this communication is generally entirely closed up in the second or third year.* The cells of which the pith is formed are at first entirely one connected body; but as the plant grows up, it is often so broke and ruptured, as to remain no longer a continuous substance.

This, as well as many other particulars in the history of the pith, corroborates the opinion of Dr. Hill,† who thinks it is formed for the purpose of moistening the clusters of the corona, and regulating it's extension; it has been supposed coeval with, or primordial to all the other parts, but he thinks it is postnate, and comes after them in the order of time, as well as in it's uses. That exhaled air gives origin to it's blebs, and the thickness of the
juices

* Duhamel *Physique des Arbres*, tom. I, p. 38.

† Hill's *Construction of Timber*, p. 66.

juices cloathing the bubble, gives it form and substance. The first season is the time of it's greatest use, and it immediately after begins to decay.

The pith has in general been represented as much more complex than it really is. It consists of a range of bladders, lying one over the other. The membrane is simple, the outline single; but as it is very difficult to procure it in this simple state, it is often seen and represented under a variety of irregular, though pleasing forms, which are occasioned by the interfections of the outlines of the blebs, as seen one over another.

A cluster in any part of the corona, protruding itself onward and outward in the growing season,* carries a part of the circle out with it. The cluster itself is a perfect piece of the wood and blea, and the bark which follows it out in it's progress perfectly cloaths it: thus is the first protrusion of the shoot made, but all this while there is no pith. The continuation of growth is made by the extension of all the parts obliquely upwards; in the course of this extension they hollow themselves into a kind of cylinder, of the form of the future branch, and by this disposition a small vacancy is made in their center. This enlarges as they increase, and as it enlarges it becomes filled with the exudation of those little bladders which remain and constitute the pith, fed from the inner coat of the pith, which already begins to form itself into a new corona. Grew seemed to think, that in some instances the pith was of posterior growth to the other parts, and derived it's origin from the bark; and that the insertions of the bark running

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* Hill's Construction of Timber, p. 99.

in between the rays of the wood, meet in the center, and constitute the pith.

OF THE SAP VESSELS.

The most numerous and the largest apertures are generally to be found in the wood, which are perceived very distinctly in a transverse section, in which the ends of the vessels are seen as cut through by the knife. The scarlet oak of America is recommended as a proper object for exhibiting them. If a short cylinder of a three years branch of this oak, a little macerated, be hollowed away with a chissel, we shall see what a large portion of the wood is occupied by these vessels; they are thick and strong, and it is easy, with some care and attention, to loosen several of them.

If a number of these, thus separated, be put into a vial of rain water, and frequently shook for several days, some will at length be found perfectly clean, these are then to be put into spirit of wine, and when that has been two or three times changed, they will be in a condition to be viewed for understanding their structure; another method of preparation has been already shewn in page 162.

These are the vessels which have been called by some writers air, by others tracheal vessels. It is, however, to be remarked, that most of those who have considered them as air vessels, refer us to the tree while in a more herbaceous state; in this case they say, that we shall find these parts filled with a fine spiral filament. As these vessels are often to be found empty, they have been supposed to answer the purposes of lungs to the plant. Malpighi asserts,

asserts, that if they are examined in winter, they often exhibit a vermicular motion, which astonishes the spectator.

Those who suppose the corona to contain the whole structure of the tree in miniature, and that it is the embryo of future shoots, suppose it to contain the vessels proper for each part, a subject that must be left to the decision of future observers.

OF THE VASA PROPRIA INTIMA.

These are the only vessels which remain to be spoken of. They are large, conspicuous, and important; their natural place is in the blea, though they are sometimes repeated in the wood and the corona. Their coats are thicker than those of any other vessels.* It is not difficult, after a successful maceration, to separate some of these vessels from the blea; in this state they appear perfect cylinders, with thick white coats, of a firm, solid, and uniform texture.

It has generally been supposed, that each of those concentric circles, which are to be observed in the transverse section of almost every tree, was the product of one year, or the quantity of wood added to the tree in that space; here, however, Dr. Hill differs again from the general opinion.

From what has been said we may deduce the following general ideas relative to the organization of trees. The most obvious and remarkable parts of a plant, or tree, are the root, the stem,

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* Hill's Construction of Timber, p. 83 and 85.

the branches, the leaves, the flower, and the fruit. The component parts of these divisions are not complicated, they are simple when compared to those of an animal, and this because the offices of the vegetable are fewer than those of the animal.

The interior part may be considered as consisting of lignous fibres, interspersed with a vast number of bladders, which are here named the cellular tissue, the *vasa propria*, and the sap vessels; though these are considered by some writers as mere air vessels.

The lignous fibres are very fine tubes, proceeding nearly in a vertical direction from the top to the bottom of the tree; they are sometimes parallel to each other, sometimes they divaricate, and often leave oblong intervals or spaces. There is great reason for supposing them to be a species of lymphatic vessels. The vacant spaces between these fibres are filled up by a vesicular membrane, lying in an horizontal direction, and which is called in this chapter the cellular tissue.

The *vasa propria* are formed of lignous fibres, but differ from the foregoing in their size, and in the juices which they contain. In the part properly called the wood, we meet with the sap vessels; but as in some states they seem as if they were formed of a silver-coloured spiral membrane, and are found without any juices, they have been supposed to be air vessels, and called the trachea, making up an arterial system, and supplying the place of the heart in animals.

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Fig. 4.



Fig. 3.

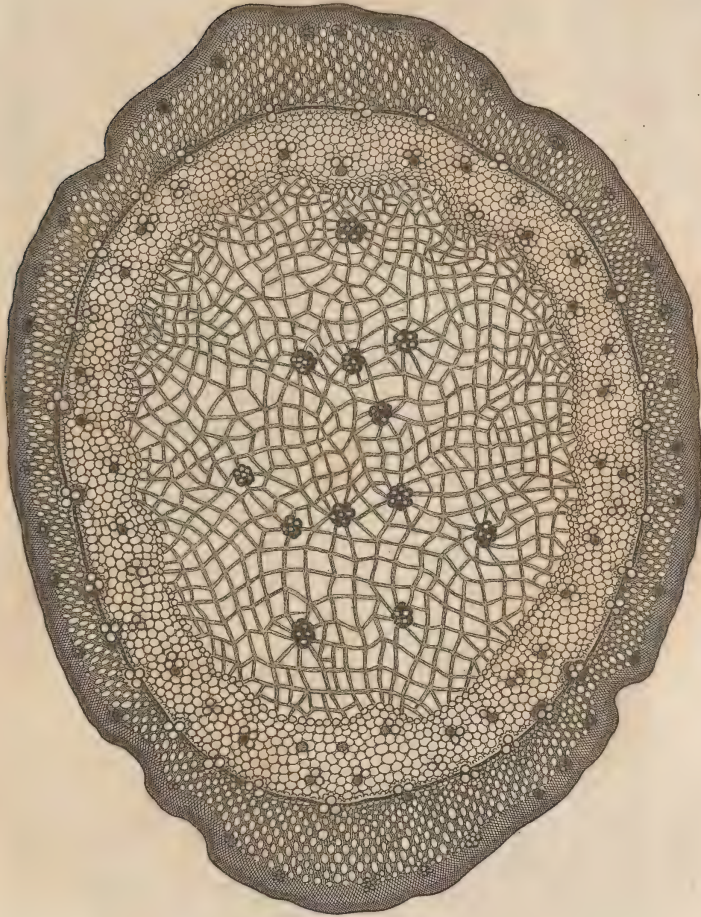


Fig. 1.



Fig. 2.

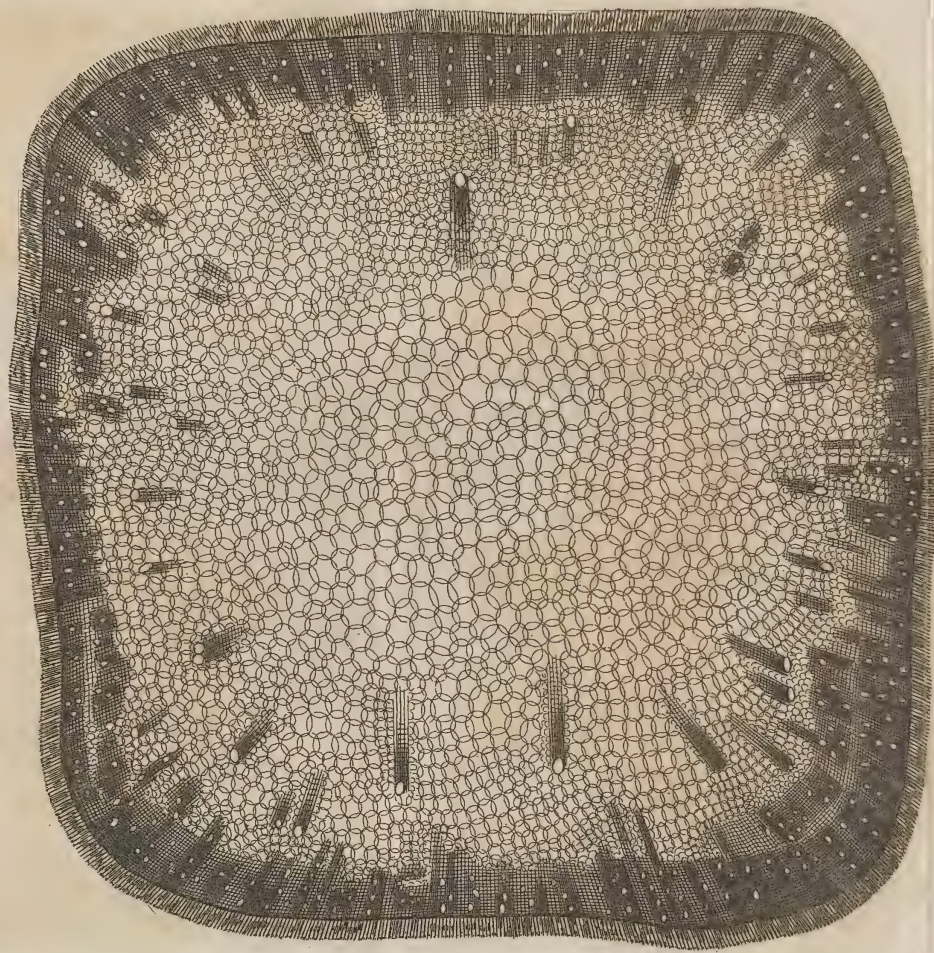
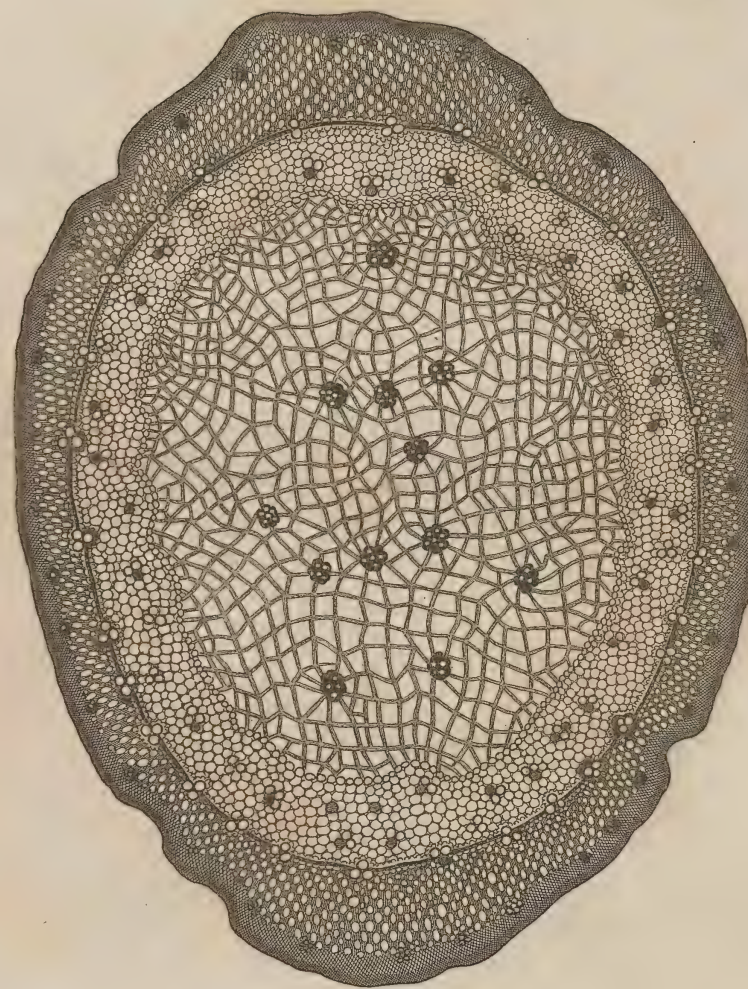


Fig. 4.



Fig. 3.



T. Milne del.

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J. Lodge scul.

The interior part of the tree may be further considered as divided into four principal concentric strata, the bark, the blea, the wood, and the pith : to these Dr. Hill has added the corona. Whatever part of a plant we examine, we find these and no more. The root, its ascending stalk, and descending fibre, are formed of one, and not three different substances. Thus the whole vegetable is reduced to one entire body. And what appears in the flower to be formed of altogether distinct parts, will be found to originate in these.

The bark, which is the exterior covering of the tree, is divided into two parts, a thin outer rind, and a much thicker inner one. The exterior one seems to be little more than a fine film of irregular meshes, the inner one composed of large blebs, leaving in some subjects large vacant spaces, which form its *vasa propria*. It is made up of several strata, laying one over the other.

Next to this is the blea, which is of an uniform structure. It is an imperfect wood, waiting only for the hand of time to be brought to perfection. The duration of the blea in this middle state depends on the internal powers and strength of the tree, being so much shorter as this is more vigorous.

The wood, including the corona, comes next ; it differs in density and duration, both from the blea, the bark, and the wood. It is made up of strong fibres. The life of the vegetable seems to reside in it ; from it all the other parts are produced. It shoots a pith inwards, and a blea and a bark outwards.

Every

Every tree may be considered as consisting of numerous concentric strata, or flakes, forming so many cones, inscribed one within the other, and whose number is almost indefinite. The most exterior contain the rudiments of the bark, the more interior those of the wood. In the germ they are gelatinous, by degrees they become herbaceous, and in process of time it assumes the consistency of wood. Thus the stem, the root, and the branch, may be considered as formed of a prodigious number of concentric vertical strata, each composed of different fascicles of fibres, which fibres are again formed of smaller ones. The spaces between these, and among the fibres, are filled up, interwoven with and connected by the cellular tissue, of which the radial insertions are formed.

The strata harden successively one after the other; the most interior stratum is that which hardens first, this is then covered by another which is more ductile, and herbaceous, and so on. From the extension in breadth the tree acquires bulk, from that in length it gains its height. The strata gradually diminish in size as they gain in length; from hence the conical figure of the root and stem, and branch. All the parts of the plant are the same, differing in nothing more than in shape and size. The roots are sharp and pointed, that they may make their way more readily through the earth. The leaves are broad, that they may more effectually catch the moisture from the atmosphere, &c. When the root of a tree is elevated above, instead of being retained under the earth, it assumes the appearance of a perfect plant, with leaves and branches. Experiment shews that a young tree may have its branches placed in the earth, and its roots elevated in the air, and in that inverted state it will continue to live and grow.

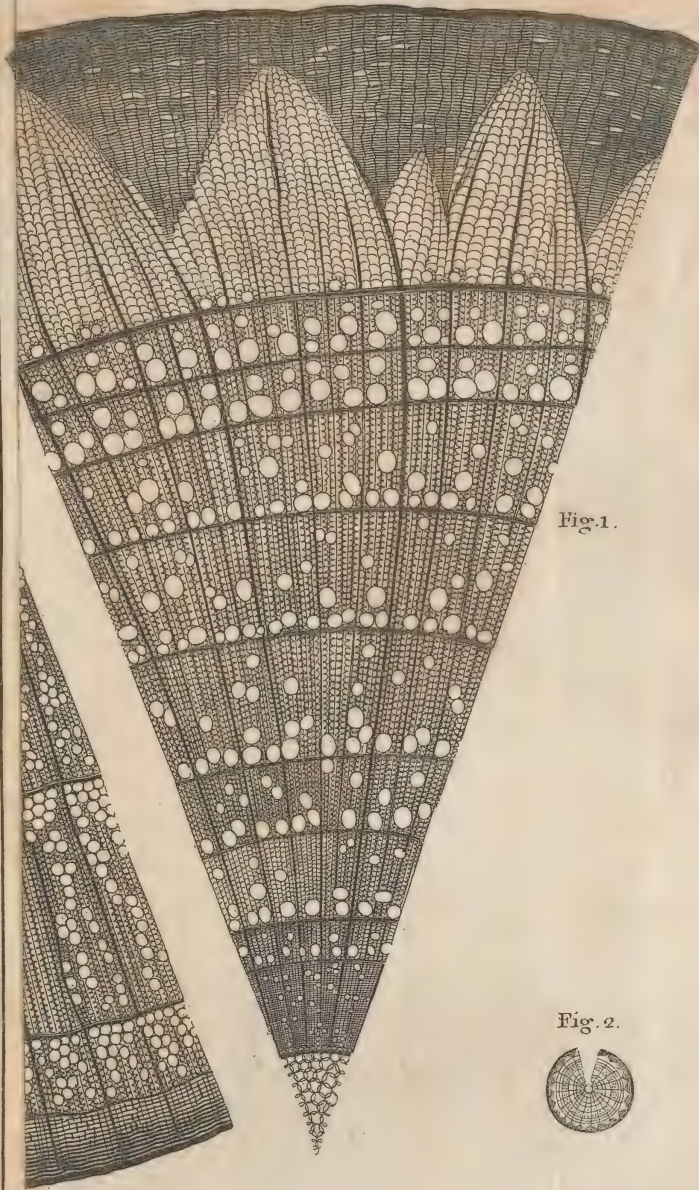


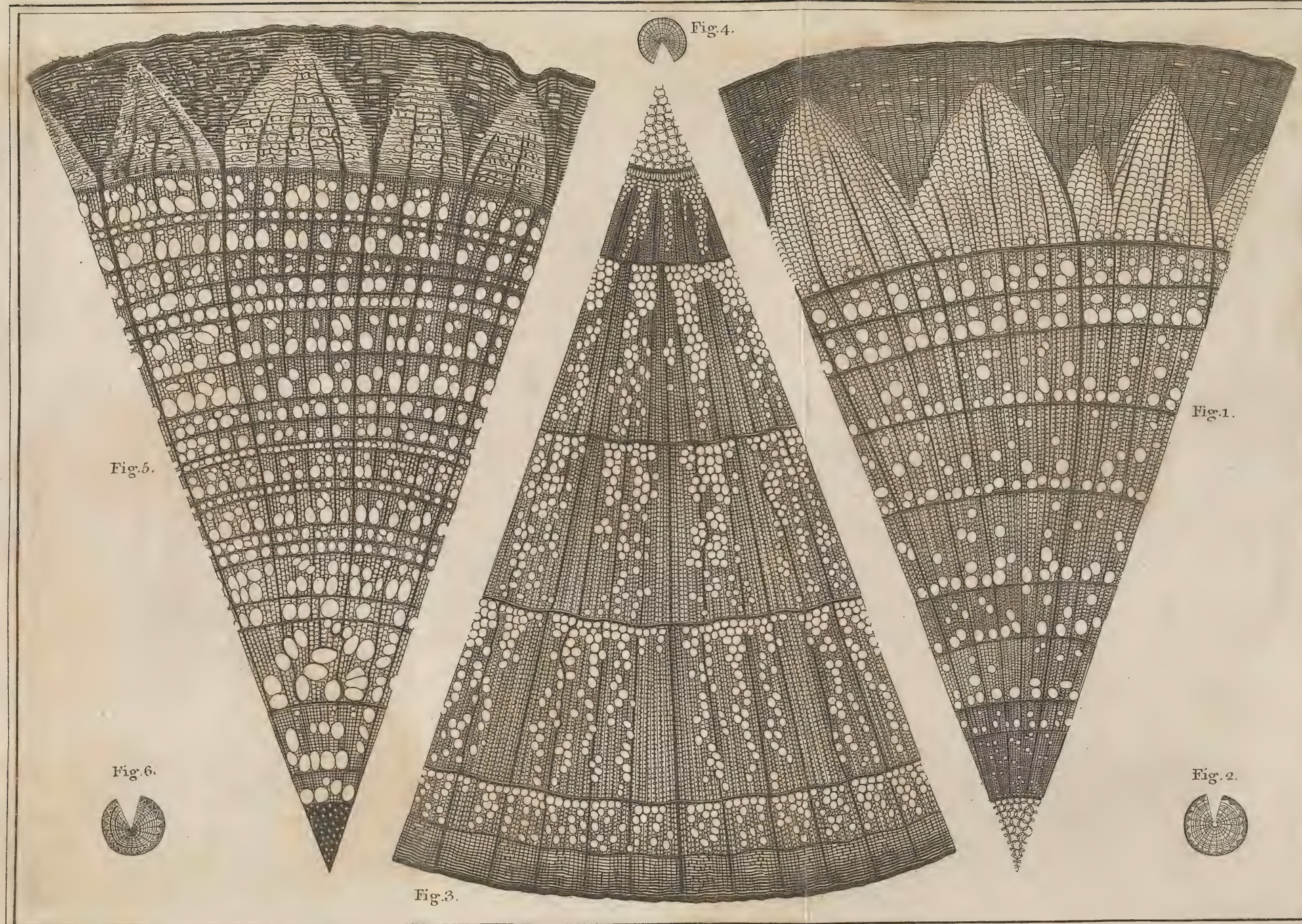
Fig. 1.

Fig. 2.

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Drawn as the Act directs. May 20. 1787.

K. Lodge sc.



T. Milne ed.

London. Printed for & Published by George Adams N^o 60, Fleet Street, as the Act directs. May 20. 1787.

J. Lodge sc.



grow. The principal source of the phenomena of vegetation is the simplicity and uniformity of their organization.

The figures in Plate XXVII. XXVIII. XXIX. are portions of transverse sections of trees and herbs. The sections were cut by Mr. Cuthance, who first brought this art to perfection, and remains unrivalled as yet in these performances.

Fig. 1, Plate XXVII. a piece of an herb growing on dung-hills, and known by the name of fat-hen; it is one of the species of orach. Fig. 2, a microscopic view of the same. Fig. 3, a magnified representation of a section of a reed that comes from Portugal. Fig. 4, the real size of the section.

Fig. 1, Plate XXVIII. a magnified view of a section of the *althea frutex*. Fig. 3, a ditto of the hazel. Fig. 5, a ditto from a branch of the lime-tree. Fig. 2, 4, 6, represent the real size of the sections.

Plate XXIX. Fig. 1, a magnified view of a section of common cane. Fig. 2, one of the bamboo cane. Fig. 3, one of sugar cane. Fig. 3, 4, 6, the real size of the sections.

C H A P. X.

OF THE CRYSTALLIZATION OF SALTS, AS SEEN BY THE
MICROSCOPE; TOGETHER WITH A CONCISE LIST OF
OBJECTS.

C RYSTALLIZATION, in general, signifies the natural formation of any substance into a regular figure, resembling that of natural crystal. Hence the phrases of crystallized ores, crystallized salts, &c. and even the basaltic rocks are now generally reckoned to be effects of this operation; the term, however, is most commonly applied to bodies of the saline kind; and their separation in regular figures from the water, or other fluid in which they were dissolved, is called their crystallization. If the word crystallization were to be confined to its most proper sense, as it seems to have been formerly, it could only be applied to operations by which certain substances are disposed to pass from a fluid to a solid state, by the union of their parts, which so arrange themselves, that they form transparent and regularly-figured

Fig. 6.



Fig. 5.

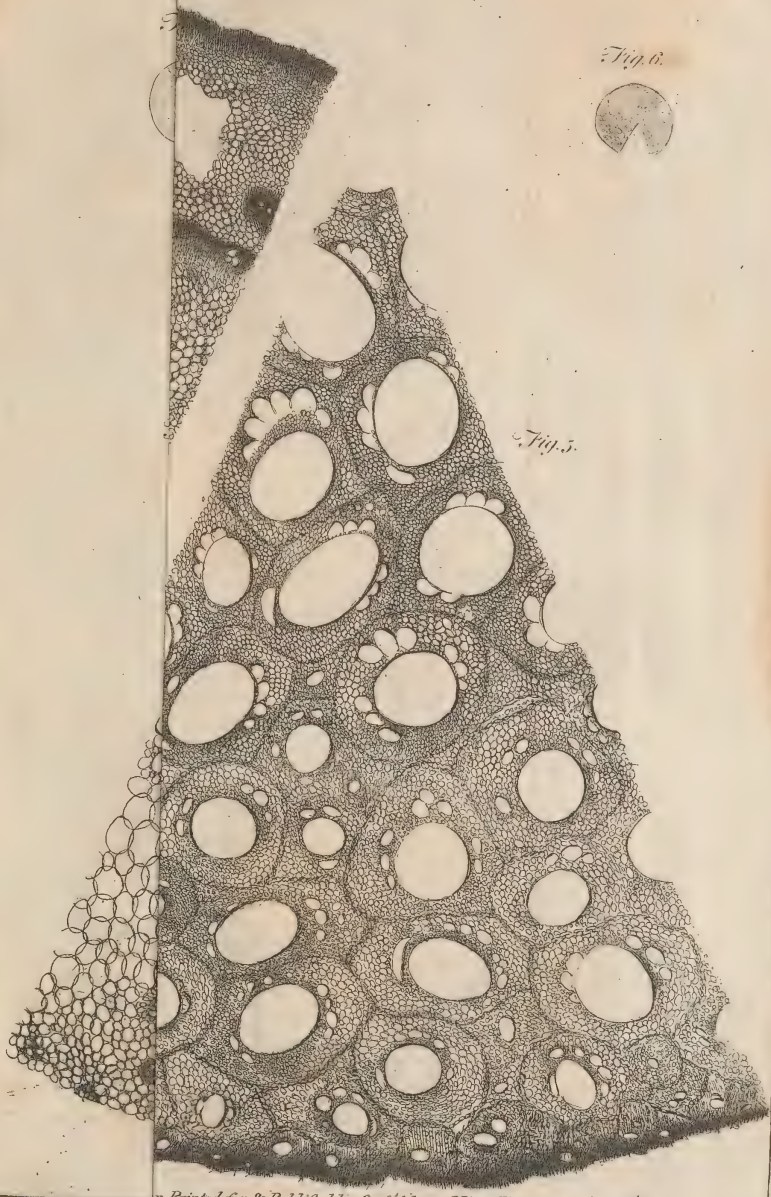


Fig. 2.



Fig. 3.



Fig. 6.



Fig. 1.



Fig. 5.

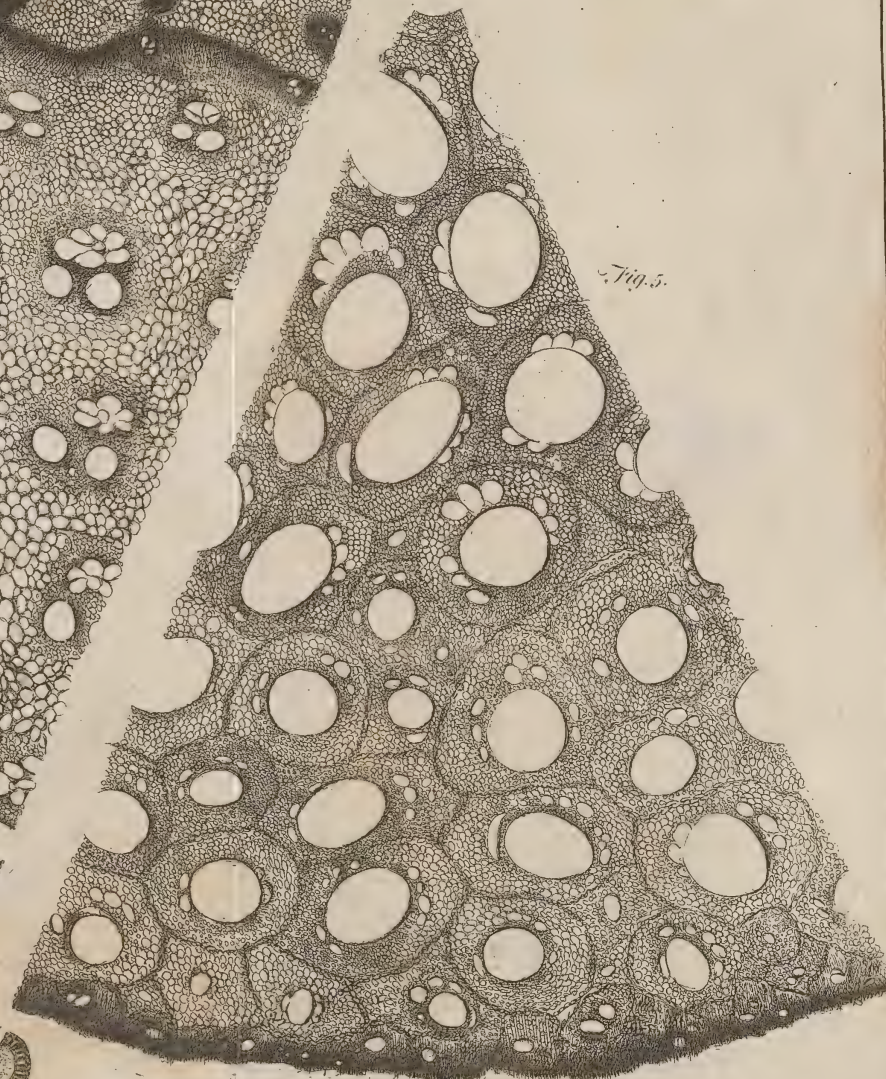


Fig. 4.





figured masses, like native crystal; from which resemblance the word crystallization has evidently been taken.*

But modern chemists and naturalists have much extended this expression, and it now signifies a regular arrangement of the parts of any body which is capable of it, whether the masses so arranged be transparent or not. Thus opaque stones, pyrites, and minerals, when regularly formed, are said to be crystallized, as well as transparent stones and salts.

The opacity and transparency of substances are justly disregarded, in considering whether they be crystallized or not; for these qualities are perfectly indifferent to the regular arrangement of the integrant parts of substances, which is the essential object of crystallization.

This being established, crystallization may be defined, an operation by which the integrant parts of a body, separated from each other by the interposition of a fluid, are disposed to unite again, and to form solid, regular, and uniform masses.

To understand as much as we can of the mechanism of crystallization, we must remark,

1. That the integrant parts of all bodies have a tendency to each other, by which they approach, unite, and adhere together, when not prevented by an obstacle.

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* Macquer's Dictionary of Chemistry, Art. Crystallization.

2. That in simple or little-compounded bodies, this tendency of integrant parts is more obvious and sensible than in others more compounded: hence the former are much more disposed to crystallize.

3. That although we do not know the figure of the primitive integrant molecules of any body, we cannot doubt but that those of every different body have a constantly uniform and peculiar figure.

4. That these integrant parts cannot have an equal tendency to unite indiscriminately by any of their sides, but by some preferably to others, excepting all the sides of an integrant part of a body be equal and similar; and probably the sides, by which they tend to unite, are those by which they can touch most extensively and immediately.

The most general phenomena of crystallization may be conceived in the following manner:

Let a body be supposed to have its integrant parts separated from each other by some fluid; if a part of this fluid be taken away, these integrant parts will approach together; and as the quantity of intervening fluid diminishes, they will at last touch and unite. They may also unite when they come so near to each other, that their mutual tendency shall be capable of overcoming the distance betwixt them. If, besides, they have time and liberty to unite with each other by the sides most disposed to this union, they will form masses of a figure constantly uniform and similar. For the same reason, when the interposed fluid is hastily taken

taken away, so that the integrant parts shall be approximated, and be brought into contact before they have taken the position of their natural tendency, then they will join confusedly by such sides as chance presents to them; they will, in such circumstances, form solid masses, whose figures will not be determinate, but irregular and various.

Different salts assume different figures in crystallization, and are, by this means, easily distinguished from one another. But besides the large crystals produced in this way, each salt is capable of producing a very different appearance of the crystalline kind, when only a drop of the saline solution is made use of, and the crystallization viewed through a microscope. For our knowledge of this species of crystallization we are indebted to Mr. Henry Baker, who was presented by the Royal Society with a gold medal for the discovery, in the year 1744. These microscopical crystals he distinguishes from the larger ones by the name of configurations; but this term seems inaccurate, and the distinction may be properly preserved by calling the large ones the COMMON, and the small ones the MICROSCOPICAL crystals of the salt.

It has not yet been shewn by any writer on the subject, why salts should assume any regular figure, much less why every one should have a form peculiar to itself. Sir Isaac Newton endeavoured to account for this, by supposing the particles of salt to be diffused through the solvent fluid, at equal distances from each other; and that then the power of the attraction between the saline particles could not fail to bring them together in regular figures, as soon as the diminution of heat suffered them to act on

each other.* But it is certain some other agent must be concerned in this operation besides mere attraction, otherwise all salts would crystallize in the same manner. Others have, therefore, had recourse to some kind of polarity in the particles of each salt, which determined them to arrange themselves in such a certain form; but unless we give a reason for this polarity, we only explain crystallization by itself. One thing seems to have been overlooked by those who have endeavoured to investigate this subject, namely, that the saline particles do not only attract one another, but they also attract some part of the water which dissolves them.

Did they only attract each other, the salt, instead of crystallizing, would fall to the bottom as a powder; whereas, a saline crystal is composed of salt and water, as certainly as the body of an animal is composed of flesh and blood, or a vegetable of solid matter and sap; if a saline crystal is deprived of its aqueous part, it will as certainly lose its crystalline form as if it was deprived of the saline part. It is, therefore, not improbable, that crystallization is a species of vegetation, and is accomplished by the same powers to which the growth of plants and animals are to be ascribed. Some kinds of crystallization resemble vegetation so much, that we can scarce avoid attributing them to the same cause.

It has been imagined, that all the great operations in nature may be reduced to two principles, those of crystallization and organization; but that often they are so concealed as to be invisible.

* Encyclopædia Britannica, p. 2329.

Fig. 2.

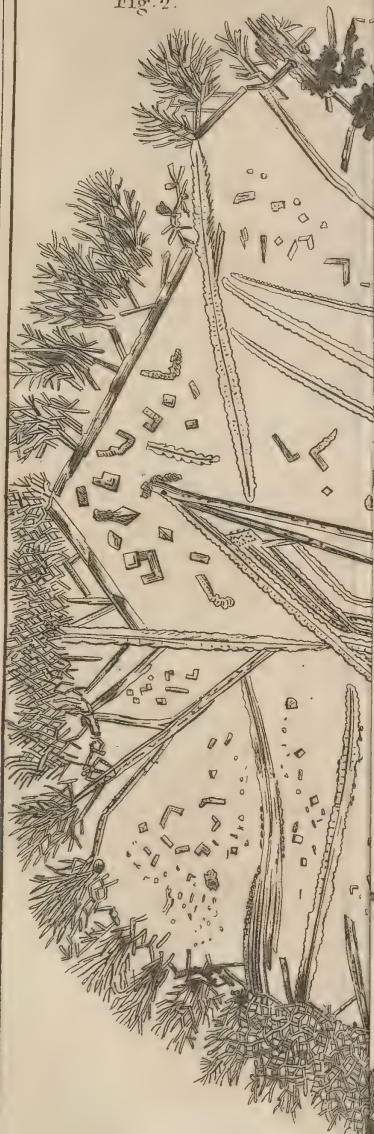
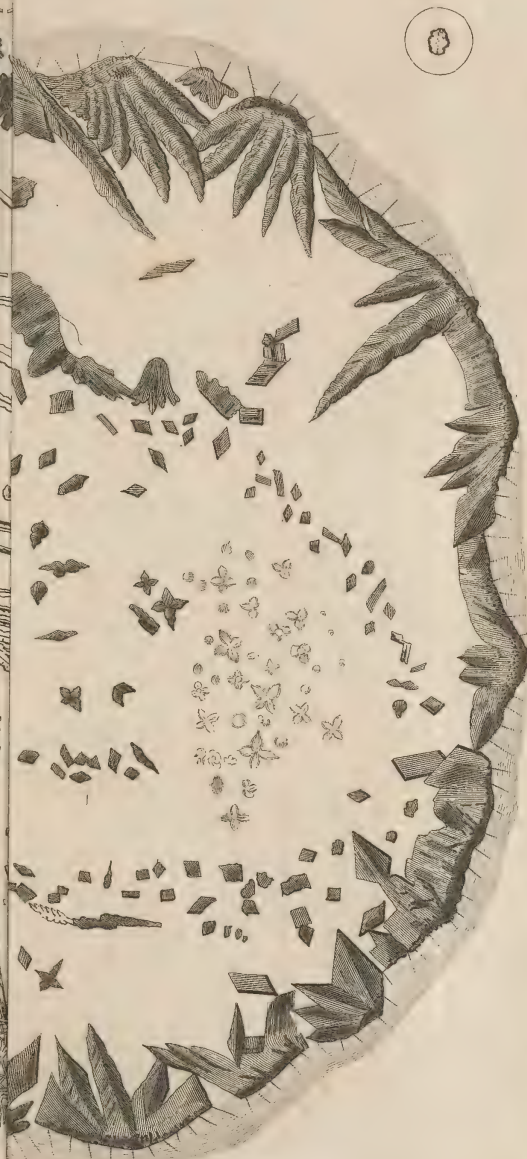


Fig. 3.



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Fig. 2.

Fig. 1.

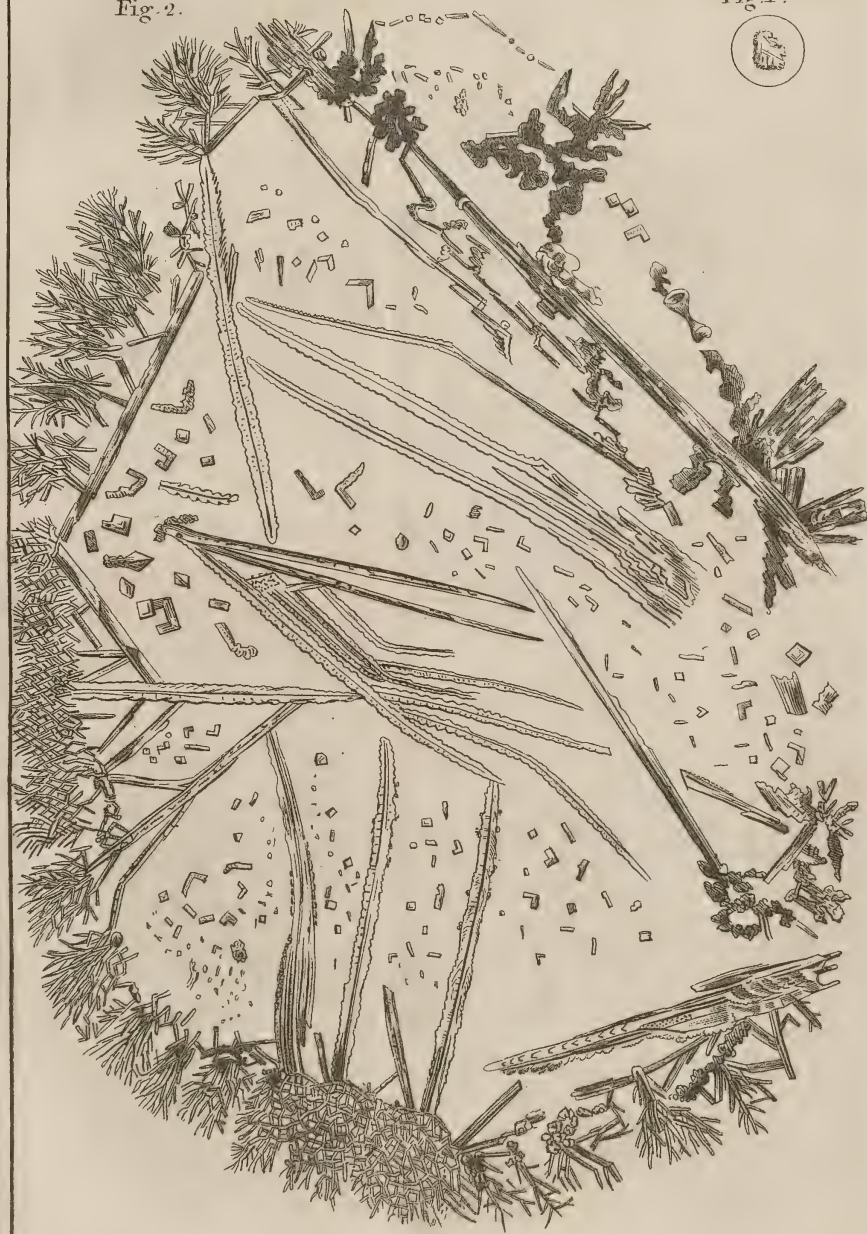
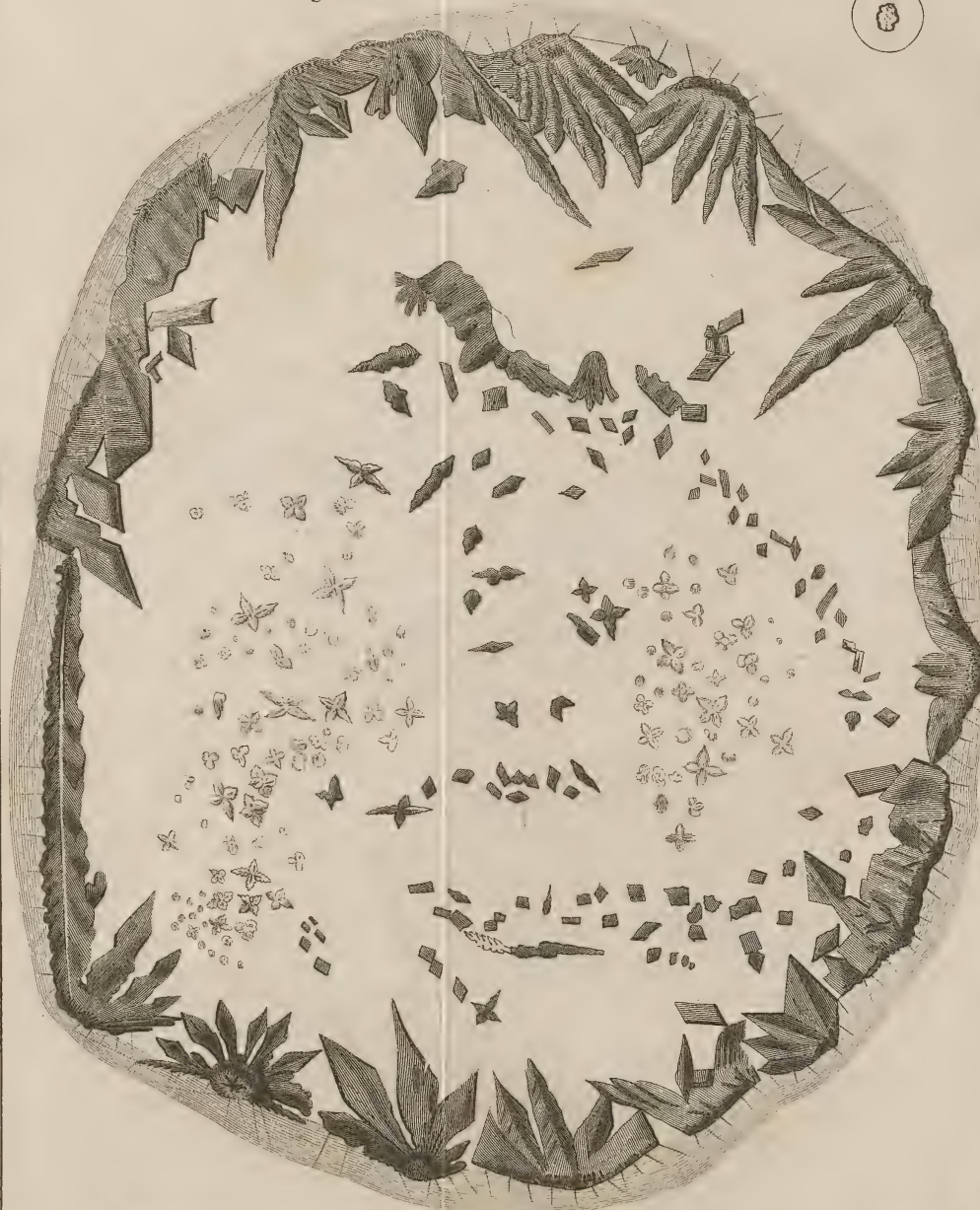


Fig. 4.

Fig. 3.





visible. Hence crystallized substances have been often mistaken for organized ones, and vice versa. They differ, however, essentially in their growth and origin. Organized beings spring from a germ, in which all the essential parts are concentrated, and they grow by intusception; whereas crystallized substances increase by the successive apposition of certain molecules, of a determined figure, which unite in one common mass. Thus crystallized beings do not grow, properly speaking; though their substance is augmented, they are not preformed, but formed daily.

We have already shewn, page 163, how to prepare the various salts for microscopical observations. The beautiful crystallizations represented in Pl. XXX. and XXXI. were produced in the manner there described.

Fig. 2, Plate XXX. shews the microscopical crystals of nitre. These shoot from the edges with very little heat, in flattish figures, of various lengths, and exceedingly transparent, the sides nearly parallel, though rather jagged, and tapering to a point; after a number of these are formed, they often dissolve under the eye, and disappear entirely; but in a little time new shoots will push out, and the process go on afresh. Beautiful ramifications are formed round the edge, and many regular figures are to be observed in different parts of the drop. Fig. 2 is the real size of the drop.

Fig. 3, Plate XXX. is a drop of distilled verdigrease, as it appeared when viewed by the microscope. There is a difference in the
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the appearance from this substance, according as the time of the application is nearer to or more distant from that in which the solution was made.

Fig. 1, Pl. XXXI. represents the microscopical crystals of salt of wormwood. The shoothings from the edges of this solution are often very thick in proportion to their length, their sides full of notches, the ends generally acute; many spear-like forms are also to be observed, as well as little crystals of a variety of figures.

Fig. 2, Plate XXXI. the salt of amber. The shoothings of this salt are highly entertaining, though the process is very slow; many spicula shoot from the edge towards the middle of the solution, and from the pointed ends of the spicula, a great variety of diversified branches may be observed, variously divided and subdivided, and forming at last, says Mr. Baker, a winter scene of trees without leaves.

Salt of hartshorn, Fig. 3, Plate XXXI. This salt shoots out from the edge of the drop into solid, thick, and rather opaque figures; from these it often shoots into branches of a rugged appearance, similar to those of some species of coral.

Fig. 4, Pl. XXXI. represents the configurations of sal ammoniac. These form a most beautiful object in the microscope: a general idea may be more easily formed, by considering the figure here exhibited, than by any verbal description.

A con-



Fig. 1.

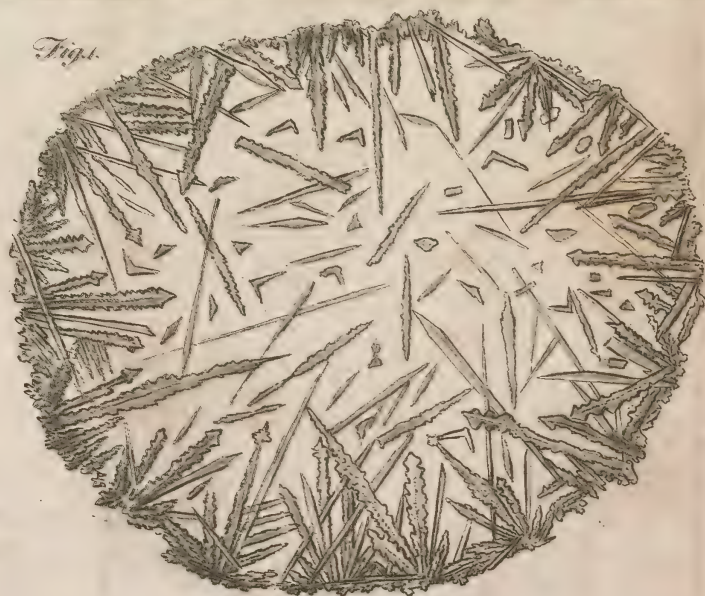


Fig. 2.



Fig. 3.



Fig. 4.





A CONCISE LIST OF OBJECTS FOR THE MICROSCOPE.

The short list here presented to the reader must, from the nature of the subject, be very imperfect; for the whole of the animal, vegetable, and mineral kingdoms, with all their numerous sub-divisions, furnish objects for the microscope; and there is not one of them that, when properly examined, will not afford instruction and entertainment to the rational investigator of the works of creation. The *Systēma Naturæ* of Linnæus may therefore be considered as a catalogue of universals for microscopic observation, each of which involves a variety of particulars. The list here given can be considered as little more than a directory, to point out to those who have only begun to study this part of natural history, a few of those objects which merit their attention, and which, from their beauties, may incite them to pursue the study with greater ardor.

“ Those who rightly consider natural things, will find them a shadow of heavenly things, a school in which God is the teacher, and all the objects of sense in heaven and earth, and under the earth, are as the letters of an universal language, in which all nations have a common interest. The Creator himself has made this use of it, revealing his will by it, and referring man to it for instruction. From hence the universal agreement between nature and revelation. Hence, also, he that can understand God as the fountain of truth, and the Saviour of men in the holy scriptures, will be better disposed to understand and adore Him as the fountain of power and goodness in the natural creation. Wherefore we go in divinity, the true philosophy will follow us as a faithful

faithful witness, and shew that the world was made, as the scriptures were written, for our instruction; and find the creation of God is the school of christians, if they use it aright.*

OF OPAKE OBJECTS.

Ores and minerals afford an immense variety of very beautiful and splendid objects. From amongst these the observer may select the peacock, or coloured copper ore, green crystallized ditto, lead ore, crystallized ditto, crystals of lead, small grained marcasites, coloured mundic, cinnabar, native sulphur, needle and other antimony, moss copper, &c. A mixture of small pieces of ores, &c. of different kinds, produces a pleasing effect. Sands, in general, exhibit something not discoverable with the naked eye. Sand from the sea-shore is often intermixed with minute shells, particularly that from Rimini, in Italy. Mr. Walker has published a specimen of the small microscopic shells which are found on our own coast. From this work we learn, that there are shell-fish as small as the minutest insects, and possessed of beauties, of which we can form no conception till we have seen them. Mr. Walker's work is entitled, "A Collection of the minute and rare Shells found on the Sea-shore near Sandwich." There is a sand from Africa full of small garnets. The ketton, or kettering stone, is a pleasing object; when examined by the microscope, we find the grain of it very different from that of other stones, being composed of innumerable minute balls, which barely touch each other, and yet form a substance much harder

* Jones' s Lectures on the Figurative Language of the Holy Scriptures.

harder than free-stone; the grains are, in general, so firmly united together at the points of contact, that it is hardly possible to separate them without breaking one or both of the grains. See Hooke's Micrographia.

INSECTS of all kinds, both foreign and domestic, are pleasing objects; but as the foreign ones are not so easily met with, I shall mention but a few of them, confining myself principally to those of this country. Among the exotic insects none appear more beautiful in the microscope than the *curculio imperialis*, Brazil, or diamond beetle; the *buprestis ignita*, a large beetle from China; the *meloe vesicatorius*, blister-fly, or cantharis of the shops; several species of locusts, grasshoppers, &c. Among the English beetles we may reckon the *scarabæus auratus*, or rose chaffer, *scarabæus nobilis*, *scarabæus horticola*, *silpha aquatica*, *cassida nobilis* and *nebulosa*. *Coccinella*, or lady-cow; of these there are great variety, both in size and colours, some red and black, others black and red, and some yellow and black. *Chrysomela*, *graminis-fastuosa*, *nitidula*, *sericea*, *melanopa*, *asparagi*, vide Plate XX. Fig. 2. *Curculio-frumentarius*, *lapathi*, *betula*, *nucum*, *scrophularia*, *argenteus*, a beautiful little insect resembling the diamond beetle, but in miniature; *curculio albinus*, very beautiful, but scarce in this country. *Leptura aquatica*, these are of various colours, as blue, purple, bronze, and crimson. *Arcuata arictis*, very common, and is often called the wasp beetle. *Cicendela campestris*, on dry banks. *Carabus nitens*, found in Yorkshire, a beautiful insect, many small carabi. *Gryllus*, *gryllo talpa*, or mole cricket; this insect, and the grasshoppers, are many of them too large to be observed at one view, but the head, fore and hind feet, elytra, &c. viewed separately,

are fine objects. Cicada, sanguinolenta, nervosa, interrupta, notonecta striata, minutissima, head and claws of the nepa cinerea, or water-scorpion, and the whole variety of cimeces, or field bugs. The wings of butterflies and moths, the chrysalis of the common white butterfly, is extremely fine.

I wish it were in my power to invite the reader to consider the pupa state of these insects, as he would find them interesting in various points of view. Perhaps the following passage from an ingenious writer may have this effect.

“Some of these creatures crawl for a time as helpless worms upon the earth, like ourselves; they then retire into a covering, which answers the end of a coffin, or a sepulchre, wherein they are invisibly transformed, and come forth in glorious array, with wings and painted plumes, more like the inhabitants of the heavens than such worms as they were in their former state. This transformation is so striking and pleasant an emblem of the present, intermediate, and glorified state of man, that people of the most remote antiquity, when they buried their dead, embalmed and inclosed them in an artificial covering, so figured and painted, as to resemble the caterpillar in the intermediate state; and as Joseph was the first we read of that was embalmed in Egypt, where this custom prevailed, it was probably of Hebrew original.”

The eggs of moths and butterflies, particularly the phalæna neustria, vide Plate X. Fig. 1 to 5. The bodies and heads of many libellulæ.

Many

Many of the ichneumon flies, sphæges and wasps, head of the hornet, sting of ditto, collectors of the bee, many sorts of muscæ, or flies with two wings, especially those whose bodies are highly coloured; acari, or ticks; phalangium cancroides, vide Plate XVIII. Fig. 1 and 6. Some spiders, but the eyes of all; the oniscus or wood louse, julus, and scolopendræ.

The feathers of peacocks, and many other birds, have a grand effect when viewed in the opaque microscope, as have also some species of ferns, mosses, and wood cut transversely. Madreporæ, milleporæ, sponges, corallines, &c. exhibit wonderful appearances, not discernible to the naked eye. Parts of echini or sea eggs, spines of ditto; these may also be cut transversely, to shew their construction. Minute shells dissected, skin of many species of fish, particularly the lump fish, Plate XVIII. Fig. 2. Soal, and the rasp fish from Otaheite, also the skins of snakes, lizards, guanas, &c. &c. An endless variety will be discovered in seeds.

The exterior form, and even the internal structure of the generality of vegetable seeds, have been supposed by some so much alike in the several kinds, and of so little curiosity and beauty in the whole, that they have scarcely been regarded by the curious; but when nearly examined, with the help of microscopes, they are found to be worthy of a greater attention; those which appear most like to one another, when viewed by the naked eye, often proving as different when thus examined, in their several forms and characters, as the different genera of any other bodies of the creation. If their external forms carry all this variety and

beauty about them, their internal structure, when laid open by different sections, appears yet more admirable.

The seed of the musk scabious is amazing in it's shape and structure; it resembles in figure an octagonal vase, with a scalloped brim; the whole is bell-fashioned, having ribs or divisions, which run down from the mouth of the vase, and thence becoming narrower, form the bottom. Between these ribs, down to the beginning of the narrow part, it is clear, though not wholly transparent, and from thence to the bottom the ribs are hairy. This vase contains a seed, which is like a pestle standing in a mortar. The pestle stands loose in an octagonal case, but the narrowness of the mouth of this vase hinders the pestle's being drawn out, because it's extremity within is rounded, and thicker than any other part of it. From it's upper end there arise five spiculated arestæ, or awns, whose little thorns are directed upwards, and are thereby prepared to cause the seed to recede from any thing that might injure it on being touched. The basen, from which these aristæ arise, is of a fine green colour, and they are of an elegant shining brown.

The seed of the great maple, which we commonly, but improperly, call the sycamore tree, consists of a pod and it's wing; two of these grow upon a pedicle, with the pods together, which makes them resemble the body of an insect with it's expanded wings: the wings are finely vasculated, and the pods are winged with a fine white down, resembling silk: this contains a round compact pellet, covered with a brown membrane, that sticks very closely to it. When this is pulled off, instead of discerning a

kernel, as in other seeds, there appears an entire green plant, folded up in a most surprizing manner. The pedicle of this is about two-eighths of an inch long, and it's feminal leaves of about six-eighths each; between these the germina of the next pair of leaves are plainly visible to the naked eye, but with a microscope they are seen with the greatest beauty and perfection. These, and a number of such other beauties in this part of the creation, are described at large by Dr. Parsons, in his work entitled, "A Microscopic Theatre of Seeds." Most kinds of seeds should be prepared for a microscopical examination, by steeping them in warm water till their coats are separated, and their feminal leaves may then be opened without laceration. But seeds, while dry, and without any preparation, are of an almost infinite variety of shape, and afford a number of pleasing objects for the microscope.

TRANSPARENT OBJECTS.

We may select from the elytra, or upper wings of beetles, many beautiful objects; the construction of these will be found to differ very much; the membranaceous wings, as in the *scarabæus foliitialis*, or small cock-chaffer; *blatta americana*, or cock-roach; all the grylli, as locusts, grasshoppers, &c. Among the cicadas, the elytra of the nervosa are the most elegant, the nerves are elevated, and curiously spotted with brown. The elytra of the cimices, or field bugs, which are a very numerous tribe, afford a great variety of objects; we may select from these, as the most beautiful, the elytra of the *cimex baccarum*, striatus, Plate XX. Fig. 4. The elytra of the *fulgora candelaria*, from China, differs essentially from all others.

The

The under, or more transparent wings of beetles excite our attention even more than the upper, or crustaceous ones; for whether we consider the delicacy of their texture, the great weight that many of them are calculated to sustain in the air, or the very curious manner in which they fold them up under the upper case, their mechanism must astonish and delight us; no two genera will be found alike, though every individual of the same genus will be exact; the wing of the forficula, or earwig, Plate XIX. Fig. 1, is an elegant specimen of the manner of their folding; this wing folds under a case not one-eighth of its size.

The under wing of the *blatta orientalis*, a beetle common in most kitchens, appears to unite the elytra and transparent wings, partaking in some degree of both.

Among the membranaceous or more transparent-winged insects, the variety is endless, each genus differing essentially from the other, some appearing full of membranes, or nerves, curiously disposed; others, again, with scarce any, like a clear piece of talc, or isinglass; some exhibit a curious ground-work of points, which, on close examination, prove short hairs, while the nerves of others are furnished with little scales, or feathers, as in some species of the gnat. The wings of many muscæ are coloured with black, brown, and white, in clouds, spots, stripes, &c. &c.

The libellulæ, or dragon-flies, alone afford a great variety, not only in form, but colour; these are all furnished with numerous and very strong nerves, adapted to the velocity of their flight; the wings of the ephemera, or May flies, are much more delicate,
these

these flies rest with their wings erect. The phryganæ differ very much from the foregoing, and also from one another; their under wings fold, and the upper ones are of a stronger texture, many of them so much resembling small moths as not easily to be distinguished from them: these are all found in the vicinity of ponds or marshy places. In the hemerobii a wonderful degree of elegance is exhibited in the disposition of the nerves, which compose their wings, each nerve being adorned with hair in a beautiful manner; there are many species of these flies equally beautiful, a specimen is given in Plate XIII. Fig. 1. The ichneumon fly has four transparent wings, the inferior ones smaller, and more delicate than the superior; the tube through which the female deposits its eggs, is an additional object well worth attention. The wings of wasps are folded longitudinally, the wings of the large bee are very curious. Gnats in general, and the various species of tipulæ, together with the clouded and variegated wings of the muscæ, tabani, &c. increase the catalogue beyond the power of enumeration; in short, there is not a wing but has its particular beauties, and will amply repay the attentive observer. The current sphinx moth connects the transparent and farinaceous wings partaking of both, and the white plumed, and many plumed moths, exhibit wings totally different from all the rest; many other small moths furnish wings sufficiently transparent for observation, the fringe or edges being remarkably beautiful.

Many small insects that are not too opaque, may be viewed and examined as transparent objects; as some of these have been particularly noticed by the early microscopic writers, it will be necessary to give some account of them, as without it the work might be deemed incomplete. Every one is acquainted with the agility
and

and blood-thirsty disposition of the flea, of the caution with which it comes to the attack, and the readiness with which it avoids pursuit. It belongs to the class aptera, has two eyes, six feet, particularly constructed for leaping, the feelers are filiform, the rostrum is inflected, setaceous, and armed with a sting; the belly is compressed. This creature is produced from eggs, which they deposit on the animals that afford them food, or affix them to the wool of blankets, rugs, &c. of these eggs are hatched white worms, which adhere closely to the body of the animal, or other substance on which they are produced; in a fortnight they come to a tolerable size, and are very lively and active; but if they are touched at this time, they roll themselves up in a ball. After about eleven days from the time of their being hatched, they seek a place to hide in, and if viewed by a microscope, will be found weaving a covering or bag, in which they assume the pupa state, where they continue from nine days to a fortnight, when having acquired sufficient strength, they burst from their confinement, perfectly formed, and armed with powers to disturb the peace of an emperor.

The flea when examined by the microscope is not an unpleasing object: it is difficult, however, to obtain such a view of it as will display the mechanism and apparatus belonging to the head. These parts are but imperfectly represented in the celebrated drawing of Dr. Hooke. The neck is long, finely arched, and much resembles the tail of a lobster; the body is covered all over with a suit of scale armour, formed of a hard shelly substance, curiously jointed and folded over one another, and yet yielding to all the nimble motion of the little animal: the edges of the scales are curiously set, with short spikes or hairs: it has two sharp

sharp eyes to look before it leaps, for which purpose it's legs are excellently adapted, for the joints are so constructed that it can fold them up as it were, and when it leaps, spring them out all at once, whereby it's whole strength is exerted, and the body often raised two hundred times it's own diameter; there are several joints in the legs; they are also very hairy, and terminated by two long hooked sharp claws; the two fore legs are placed very near the neck, and often conceal the proboscis from our view, the other four join all at the breast: the flexure of the two fore ones is contrary to that of the hinder ones: the proboscis, or sucker, with which it penetrates the skin, is placed at the end of the snout, and is not easily seen, except the two fore legs are first removed; in it are included a couple of darts or lancets, which, after the proboscis has made an entrance, are thrust farther into the flesh, and make the blood flow from the adjacent parts, and occasion that round red spot, with a hole in the center of it, called a flea bite.

The bed bug is another nauseous insect, "that intrudes upon the peace of mankind, and often banishes that sleep which even anxiety and sorrow permitted to approach: the night is the season when the bed bug issues from it's retreat to make it's depredations: by day it lurks in the most secret parts of the bed, takes the advantage of every chink and cranny to make a secure lodgement, and contrives it's habitation with so much art, that scarce any industry can discover it's retreat: but when darkness promises security, it then issues from every corner of the bed, drops from the tester, and crawls from behind the arras, and travels to the unhappy patient, who vainly wishes for rest and refreshment."

These insects are as disagreeable from their nauseous stench, as their unceasing appetites. Linnæus thinks that they are not originally of European growth, but were imported from some other country. It has two brown small prominent eyes, two antennæ, and a crooked proboscis, which lies close under the breast. Instead of wings, we find on the first ring of the belly, two flat pieces which entirely cover it, and extend towards the sides. These plates, the trunk and the head, are amply set with hairs. The proboscis is divided transversely into four parts, which are probably so many articulations; this piece is best seen on the under side of the bug. It has six legs, each of which has three joints; the skin is chagrined, and the separation of the rings usually marked by a smooth shining band. On the belly, at a small distance from the edge, you may perceive a set of circular spots, two on each ring, except the last; these are the spiracula. Examined internally we find one large artery, a stomach, and intestines. The instant it perceives the light it endeavours to gain its habitation, and seldom fails in making good its retreat.

Of the louse. Various as are the antipathies of mankind, all seem to unite in their dislike to this animal, and to regard it as their natural and most nauseous enemy. "Whenever wretchedness, disease, and hunger, seize upon man, the louse seldom fails to add itself to the tribe, and to increase in proportion to the number of his calamities."

When the human louse is examined by the microscope, its deformity fills us with disgust. In the head we may distinguish two fine black eyes, near this are the two antennæ: the fore part of the head is rather long, the hinder more obtuse or rounder; there

there is a small part that projects from the nose or snout, this serves as a sheath or case to the proboscis, which the creature thrusts into the skin to draw out the blood and humours which are it's destined food, for it has no mouth which opens in the common way.

This proboscis has been estimated to be seven hundred times smaller than a hair, and is contained in another case within the first, and can be drawn in or thrust out at pleasure: the skin is hard and transparent. From the under side proceed six legs, each of which has five joints, and terminates in two unequal hooked claws, these it uses as we would a thumb and finger; there are hairs between the claws, as well as all over the legs; the body finishes in a cloven tail, which is generally covered, and partly concealed by hairs.

From the extreme transparency of it's skin, many of it's internal parts may be seen, as the various ramifications of the veins and arteries, and the peristaltic motion of the guts. When the louse feeds, the blood is seen to rush like a torrent into the stomach, and it's greediness is so great, that the excrement contained in the intestines is ejected at the same time, to make room for this new supply. There is scarce any animal that multiplies so fast as this unwelcome intruder, the moment it is excluded from the egg it begins to breed.

It would be endless to describe the various creatures which go under the name of lice, and swarm upon every part of nature. The reader who wishes for a more particular account of those

which infest various animals; would do well to look into Rhedi's *Treatise de Generatione Insectorum*.

The spider is another insect which is often examined by the microscope, and certainly affords much matter for observation. "Formed for a life of rapacity, and incapable of living but by blood, all it's habits are calculated to deceive and surprize; it spreads toils to entangle it's prey; it is endued with patience to expect it's coming, and is possessed of arms and strength to destroy it when fallen into the snare.

" ——— To heedless flies the window proves
A constant death; where, gloomily retired,
The villian spider lives, cunning and fierce,
Mixture abhorr'd; amid a mangled heap
Of carcases, in eager watch he sits,
O'erlooking all his waving snares around.
Near the dire cell the dreadless wanderer oft
Passes, as oft the ruffian shews his front;
The prey at last ensnar'd, he dreadful darts
With rapid glide along the leaning line;
And, fixing in the wretch his cruel fangs,
Strikes backward grimly pleas'd: the flutt'ring wing
And shriller sound declare extreme distress,
And ask the helping hospitable hand."

The eyes of the spider are a very beautiful microscopic object, viewed either as transparent or opaque; they have generally eight, two on the top of the head, that look directly upwards; two in the front, a little below the foregoing, to discover what
passes

passes before it; and on each side a couple more, one whereof points sideways forward, the other sideways backward; so that it can see almost all round it. They are immoveable, and seem to be formed of a hard, transparent, horny substance. The number of eyes is not the same in all the species of the spider. They have eight legs, with six joints, thickly beset with hairs, and terminating in two crooked moveable claws, which have little teeth like a saw; at a small distance from these claws, but placed higher up, is another, somewhat like a cock's spur, by the assistance of which it adheres to its webs; but the weapon wherewith it seizes and kills its prey is a pair of sharp crooked claws, or forceps, placed in the fore-part of the head. They can open or extend these pincers as occasion may require; when undisturbed, they suffer them to lie one upon another. Mr. Leeuwenhoek says, that each of these claws has a small aperture, or slit, through which he supposes a poisonous juice is injected into the wound it makes.

The exuvia of the spider, which may be found in cobwebs, being transparent, is an excellent object; and the fangs, or forceps, may be easier separated from it, and examined with more exactness than in a living spider. The contexture of the spider's web, and their manner of weaving them, have been discovered by the microscope. The spider is supplied with a large quantity of glutinous matter within its body, and five dugs, or teats, for spinning it into thread. This substance, when examined accurately, will be found twisted into many coils, of an agate colour, and which, from its tenacity, may be easily drawn out into threads. The five teats are placed near the extremity of the tail; from these the aforesaid substance proceeds; it adheres to
any

any thing it is pressed against, and being drawn out, hardens in the air. The spider can contract or dilate at pleasure the orifices through which the thread is drawn. The threads unite at a small distance from the body, so that those which appear to us so fine and single, are notwithstanding composed of five joined together, and these are many times doubled when the web is in formation.

The gnat is a beautiful object for the microscope. We have already noticed the curious manner in which they dispose their eggs upon the surface of the water. These, as they come to maturity, sink deeper. There is no species of insect more troublesome to mankind than the gnat: others give more pain with their stings, but it is only by accident we are stung by them; but the gnats thirst for our blood, and follow us in whole companies for it. There are many marshy places in our country, where the legs and arms of the inhabitants are kept swelled all the summer by the biting of these insects: in many other countries they are yet more troublesome than with us. It is one of those insects which pass through two states of life, seemingly quite opposed to each other; in one condition swimming in the water like fish, in the other becoming like the birds, inhabitants of the air.

From the egg proceeds the larva, in which state it is most happily suited to shew the several operations of life; for a moderate magnifying power will discover what passes within its transparent body. It has a large scaly head, with two large antennæ, besides several hairy parts, and articulated bristles near the mouth, which are in continual motion. If the worm be dissected, the feet of the gnat may be found folded up in the
divisions

divisions of the thorax ; the abdomen is divided into eight rings, from the edges of each of which three or four bristles proceed. The tail is divided into two parts, of very different forms ; by one of these it can steer itself any way, in the other we may discover two pulmonary tubes, through which the insect breathes. The larva has a power of moistening the tail with an oleaginous liquor, by which means it can suspend itself on the surface of the water. On agitating the water, the worms descend with precipitation to the bottom ; but they soon return to the surface, to breathe the air through the tube that is annexed to their tail. They pass from this state into that of the pupa, which is the gnat inclosed in a thin skin, under which it is formed and strengthened, the organs of respiration are changed, breathing in this state through a couple of horns, which are placed near the head, keeping itself rolled upon the surface of the water, though on the least motion it descends, unrolling itself, aided by the oars near the tail.

From the spoils of the pupa, a little winged insect proceeds, whose every part is active to the last degree, and whose whole structure is the just object of our admiration. Its head, adorned with feathers, is a fine microscopic object ; but the proboscis may be deemed one of the most curious instruments in the insect creation. It consists of a scaly sheath ; at about two-thirds from the end of this there is an aperture, through which it darts four pieces ; one of these is, however, no more than the case in which the others lie concealed.

The proboscis of the gnat consists of a great number of extremely delicate pieces, all concurring to one purpose; this is the instrument with which it strikes the flesh, and sucks the blood of animal bodies. The only part exhibited to the naked eye is the sheath, which contains all the other pieces. The sheath is a cylindric tube, which is slit in such a manner, that the insect can separate it from the dart, and bend it more or less in proportion as the dart is plunged into the wound. From this tube the sting is darted, which consists of five or six blades or lancets, lying one over the other; some of these are sharpened like a two-edged sword, while others are barbed, and have a vast number of cutting teeth. When this bundle of blades is introduced into a vein, the blood rises up the blades as so many capillary tubes. The moment the gnat lances it's dart into the flesh, two or three drops of a fluid are insinuated by it into the wound. It is this fluid which is supposed to cause those insupportable itchings that we feel when stung by this little creature.

Plate XVI. Fig. 1, is the proboscis, or that apparatus of a tabanus with which it pierces the skin of horses and oxen, and nourishes itself with their blood. The singular and compound structure, together with the admirable form and exquisite beauty of this apparatus, discovers such a view of the wisdom, power, and greatness of it's infinite composer, as must strike with admiration every contemplative observer, and lead him to reflect on the weakness, impotence, and nothingness of all human mechanism, when compared with the immense skill and inimitable finishing displayed in the subject before us. The whole of this formidable apparatus is composed of six parts, (exclusive of the two guards, or feelers, a a,) all of which are inclosed in a fleshy
case,

case, which in the figure is totally removed, as it contained nothing remarkably different from that of other insects with two wings. The guards or feelers, a a, are of a spongy or fleshy substance, and are grey, covered with short hairs; they are united to the head by a little joint of the same texture, which in this view of the object could not be shewn. These guards are a defence to the other parts of the apparatus, as they are laid upon it side by side whenever the animal stings, and by that means preserve it from external injury. The two lancets, b b and B, evidently open the wound, and are of a delicate and tender structure, formed like the dissecting knife of the anatomist, with a sharp point and slender edge, but gradually increasing to the back. The two shaped instruments, c c and C, appear as if intended to enlarge the wound, by irritating the parts round it; to accomplish which, they are jagged, or toothed; they may also serve, from their hard and horny texture, to defend the tube e E, which is of a softer nature, and tubular, to admit the blood, and convey it to the stomach; this delicate part is inclosed in a case, d D, which entirely covers it. These parts are drawn separately at B, C, D, E. De Geer observes, that it is only the females that suck the blood of animals; and Reaumur declares, that having made one disgorge itself, the blood it threw up appeared to him to be more than the whole body of the insect could have contained.

The exuvia, or cast skin of insects, being exceedingly transparent, are well adapted for observation, as they exhibit the outward appearance of the little animal; among these we may reckon those of spiders and cimeces, but particularly the forficula, or earwig, which is an elegant exuvia. The stings of insects vary

not only in their form, but also in their apparatus ; most of them require dissection, as the stings (for they have generally two) are inclosed in a hard sheath, or case, to which is added a pair of feelers. The stings of bees, wasps, &c. are barbed, while that of the chrysis is serrated, or notched like a saw.

The head of insects is furnished with an instrument, or proboscis, various as the insects themselves, but all deserving the utmost attention, being admirably adapted to their different uses and purposes. Among the most remarkable are the bed bug, flea, gnats, empis, conops, &c. to which we may add the singular one of the tabanus, which we have just now described. We have also so fully described the bee's apparatus, page 362, that it is unnecessary to enlarge on it here.

The antennæ of moths, butterflies, and most other insects, display as great beauty in their formation as they are endless in their variety ; the distinguishing characters of many of them have been described, page 175 ; and that of the lepas antiferæ in particular, page 359.

The eyes of insects are singularly constructed, but this structure is not discoverable without the assistance of the microscope ; the eyes of the libellula are hexagonal, vide Plate XVI. Fig. 3 ; while those of lobsters are square, as may be seen Plate XVI. Fig. 5.

Hair of animals, as the mouse, goat, large bee, and many species of caterpillar, particularly the tufts on the head and tail of the larva of the phalæna antiqua, offer many beauties to the
curious.

curious observer. The bristles of a hog, cut transversely, appear tubular, and the root of hair is evidently bulbous.

The muscular fibres, and every anatomical preparation that can be brought under the microscope, are pleasing objects; the reader will meet with many curious and interesting observations on the hairs, the muscles, nerves, and other parts of the human body, in Fontana's Treatise on the Venom of Vipers, printed for Murray.

The legs of all insects appear very much diversified, and their mechanism truly astonishing, according with their different occupations, as particularized page 179.

Scales of fish, as foals, roach, dace, salmon, eels, &c. as also the scales of snakes, lizards, &c. &c. A specimen of scales is given, Plates X. and XIX. The scales form a light, but at the same time a solid and smooth covering to the fish, they hinder the fluid from penetrating the body, for which purpose they are laid in a kind of natural oil; they serve also as a protection, and break the force of any accidental blow, which may be the reason why river fish have larger and stronger scales than sea fish, being more liable to accidents.

Feathers, and parts of feathers, are not to be passed by or unnoticed; but it is impossible to point out any of these in preference to others, as each has its peculiar beauties; the plumula of these have generally in the microscope the appearance of a large feather; the pith contained in the quill, if cut transversely, and examined, exhibits an admirable reticular texture. Many other parts of birds will afford a great variety of curious objects, par-

ticularly the egg: Mr. Martin says, that the internal spongy substance of bones may be better observed in those of birds than of any other animal; even the feathers or scales of a moth's wing amply repay the observer; these also vary in their texture and figure; but the largest, and most commonly applied, are from the body of the sphinx stellatarum, or humming-bird moth; a specimen is given, Plate XVI. Fig. E F H I.

Transverse sections of all kinds of wood, especially those of a pithy or soft nature; their beauty will be seen by the figures in Plates XXVII. XXVIII. XXIX.

The flowers of most grasses, with all the varieties of mosses; the farina of flowers; mouldiness, which evidently appears to vegetate; all the kinds of sponge, sea weeds, particularly the conservæ, which is jointed like a cane. The extensive family of corallines present an elegant appearance; the most beautiful are the sea hair, sea fir, fickle, fox tail, &c. described by Ellis.

Dissected leaves, which shew the fibres and nerves; the human intestine, injected with wax, is a fine object, as are many other anatomical preparations. The seed of the silver-rind birch appears like an insect; seed of the quaking grass is also much admired, as is the leaf which covers the seed of sorrel. Among artificial productions, the edge of a razor, and point of a fine needle, as also fine cambric, evidently discover the inferiority of the workman; particles from the collision of flint and steel, wire melted by the electric explosion, &c. &c. &c.

The

The preceding objects being most of them easy to be procured by those who have leisure, and are frequently in the country, an endless variety may be added to them; but those lovers of the microscope, who may have neither leisure nor opportunity to search for themselves, may be supplied with all, or most of them, or indeed with objects to almost any extent, by applying to me, No. 60, Fleet-Street, London.

Besides the above, there are an immensity of objects which can only be examined alive, or when found, such as polypes, minute aquatic insects; animalcula, of various infusions, as eels in paste, vinegar, &c. The eyes and teeth of snails, the circulation of the blood in the tail of fishes, &c. The shooting of salts, &c.

The following extract from a truly philosophical writer, will, I hope, prove acceptable to the reader, as well as form a proper conclusion to this work.

“How admirable are the works of God! how excellent the operation of his hands!

I considered plants, and animals; four-footed beasts, and creeping things.

In all was manifested infinite wisdom, and an excellent workmanship, that I could not comprehend.

Yet so much was made known unto me, as declared the power and goodness of God, and the continued agency of the great Creator, and Lord of all things.

I beheld

I beheld the caterpillar issuing from it's egg, on the very plant needful for it's support:

For there the parent fly had placed it, that it might have whereon to feed.

It enjoys the repast, it weaveth it's web, and, preparing for it's end, buildeth itself a rich tomb.

It resteth from it's labours, and sleepeth the sleep of death.

At the appointed time it is raised again, and the great Creator of all things giveth it a new life.

It leaveth it's ashes in the tomb, and ascends, with a more beauteous form, into the regions of the air.

How glorious are it's wings! and it's limbs how delicate!

It is covered with a rich plumage; and furnished with myriads of eyes; to behold all around.

With it's trunk it surpasseth the art of the chymist, and extracteth from flowers the most delicious sweets.

It forlakes the leaf whereon it was first nourished, rejoicing in the bounty of it's Maker.

But, at his command, it is mindful of it's offspring, and provides for the safety and sustenance thereof.

With anxious care it seeketh out the plant which God hath given for it's infant worms.

Though it feedeth not thereon, neither careth for the verdant leaves, yet is it led with unerring search, and never faileth in it's choice.

It curiously spreadeth forth it's eggs; and without thought, filleth it's appointed task.

The bee just raised to life, without a teacher skilfully forms her cell.

The fage's art is known to her: she has discovered the most capacious form, and the best division of space.

Without scale or compass she nicely measureth her work, and with great care strengtheneth it's foundations.

She layeth her foundations in the upper part; she buildeth downwards, even unto the ground; and exquisitely finisheth her work, surpassing the art of man.

Behold! we perceive as yet but a small portion of his works; we see the operations of his hands as through a glass darkly; yet how excellent do they appear!"*

* Hymns to the Supreme Being, in Imitation of the Eastern Songs.

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